# STUDIES ON TASMANIAN RAINFOREST LICHENS

by

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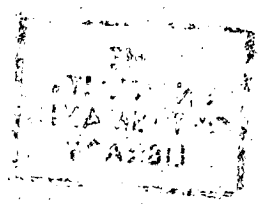

## DECLARATION

Except as stated herein, this thesis contains no material which has been accepted for the award of any other degree or diploma in any university and, to the best of my knowledge and belief, contains no copy or paraphrase of material previously published or written by another person, except where due reference is made in the text.

Gintaras Kantvilas

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## ABSTRACT

This thesis deals with the history of lichenology in Tasmania, the composition of the Tasmanian rainforest lichen flora and the ecology of rainforest lichens. The first part (history) provides a context for the floristic and ecological sections and traces the development of lichenology from the first collections to the present. Two periods of lichenological activity are apparent in Tasmania. The first, in the 19th Century, saw the discovery and description of much of the flora. The second, which commenced within the last two decades, has involved the relearning of early knowledge and its reappraisal in terms of modern taxonomic principles.

In the present study, 208 species, comprising 128 macrolichens and 80 crustose species, are reported from Tasmanian rainforest. The inventory of macrolichens is considered virtually complete and an identification key for the species is provided. Crustose lichens remain poorly known and only the more common or distinctive species are included. Brief descriptions for all species, as well as habitat and distribution data, are provided. Approximately 60% of the species belong to the "austral cool temperate" phytogeographical element, although the "Australian" and "cosmopolitan" elements are also well-represented. There are very few endemics and 76% of the flora also occurs in New Zealand. Some lichens are confined to rainforest but many species occur also in other high-rainfall vegetation. Most species are widespread within rainforest but large scale disturbance and the fragmentation of rainforest stands poses a threat to their survival.

The vertical distribution of lichens in rainforest is investigated by direct gradient analyses and by the numerical techniques of ordination and classification. Lichens respond to a complex environmental gradient which extends from the forest floor to the canopy. This height gradient entails the components of micro-climate and substrate age, with the shadiest, oldest substrates near the forest floor and the most exposed, youngest substrates in the canopy. The character of the host tree and the local structure of the forest modify the effects of height. Individual lichens mostly have broad, overlapping distributions with recognisable optima. Similarly, aggregations of species characterise particular habitats along the

complex height gradient. Relationships between lichen diversity, height and substrate age are also apparent.

A classification of lichen vegetation in rainforest at Little Fisher River, northern Tasmania, is undertaken using phytosociological techniques. 11 communities are described and, apart from minor compositional details, these are widespread in Tasmanian rainforest. A numerical classification provides supporting evidence for the phytosociological classification and the relative merits of the two approaches are discussed briefly. A scheme of inter-relationships and successional pathways among the communities is proposed. This scheme is supported by an ordination which illustrates the ecological and distributional trends described. Ecological centres of distribution for bryophytes and different lichen growth-habit groups are also illustrated. Three environmental gradients are of particular importance: age of substrate/ height above ground, moisture and substrate texture. These results independently support the analyses of environmental gradients in the vertical distribution study. Furthermore, the aggregations of species previously identified along the vertical gradient are referable to phytosociological units.

# I INTRODUCTION

# A. STATUS OF LICHENOLOGY IN TASMANIA

## Early history of lichenology in Tasmania*

### 1. Contributions of the early explorers

The earliest published account of an Australian lichen relates to Baeomyces reteporus Labill. (now known as Cladia retipora (Labill.) Nyl.). This was first collected in Tasmania by Jacques Julien de Labillardière (Labillardière 1807), the botanist and chief scientist on a French expedition commanded by Bruni D'Entrecasteaux. The French were in Australian waters for nearly four years, including two periods in south-eastern Tasmania (April 1792 and January 1793). Labillardière's account of the botany of the voyage, Novae Hollandiae Plantarum Specimen (published in two parts in 1804 and 1807), is the first botanical work devoted to the flora of Australia and Tasmania. 265 plant species are described but Baeomyces reteporus is the only lichen included, although Labillardière did collect other lichens during the expedition. The collecting locality for Baeomyces is given as 'Capite Van Diemen', a general name used by Labillardière for all his collections from Tasmania.

The voyage of D'Entrecasteaux was followed by that of another Frenchman, Nicolas Baudin. The expedition was in Australian waters between 1800 and 1804 and, in addition to landfalls on the mainland, explored Tasmania's east coast and King Island. Extensive botanical collections were made by Leschenault de la Tour and his assistant, A. Guichenot, as well as by the zoologist, F. Peron. No comprehensive account of the botany of the voyage was completed, although isolated collections are cited in early lichenological works. For example, Sticta delisea Fée, described from King Island, was almost certainly collected on this expedition. It also appears that at least part of Labillardière's collection of Tasmanian lichens, deposited in Florence (Herb. Webbianum), was in fact collected by Peron (D.J. Galloway pers. comm.).

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* This section is abridged from Kantvilas, G. (1983) A brief history of lichenology in Tasmania. Pap. Proc. R. Soc. Tasm. 117: 41-51.

In 1801, the British Government commissioned Matthew Flinders to undertake a survey of the south coast of Australia. Accompanying the voyage was the Scottish botanist, Robert Brown. No landfalls were made in Tasmania but Brown later spent nine months in the state, arriving in 1803 with Lt. Bowen and the first settlers. The botanical results of Brown's visit to Australia were published in 1810 in his Prodromus Florae Novae Hollandiae et Insulae Van Diemen. The work dealt with 4,200 plants but included no cryptogams. However, a list of 58 lichens recorded by Brown (but lacking locality data) was published in the appendix to Flinders' A Voyage to Terra Australis (Brown 1814). Brown's ambition to publish a more detailed catalogue of lichens was not realised and, after his death in 1858, his collection remained in obscurity in the British Museum. Eventually the Reverend James Crombie, a leading British lichenologist, published a catalogue of lichens from Brown's herbarium (Crombie 1880). It contained 75 species, including 12 descriptions of new lichens, three by Crombie, seven by the French lichenologist, William Nylander, and two from Brown's original notes. Forty-two of these lichens were from Tasmania, the localities being 'Derwent River', 'Table Mt. (=Mount Wellington) and its foothills' and 'Risdon Cove'. However, at least some of these localities should be treated with extreme caution. Two of the new species from Mount Wellington, Parmelia australiensis and Chondropsis semiviridis, have never since been reported from Tasmania. Both occur along the arid coast of the Great Australian Bight and it seems likely that either Brown or Crombie muddled their labels (see Paulson 1930, Filson 1976).

## 2. The early colonial period

With the establishment and growth of the Australian colonies, the main thrust of botanical exploration shifted from the sea-faring botanist confined to the coast, to the resident collector with access to the inland. Sir Joseph Banks, who had previously ensured that botanists were enlisted for the British voyages of discovery, began to send collectors to the colonies or to recruit the settlers themselves. On the death of Banks in 1820, this task fell to William Jackson Hooker.

One of Hooker's earliest contacts in Tasmania was Robert William Lawrence, a young man of leisure with an avid interest in botany. Their correspondence began in 1830 (see Burns & Skemp 1961)

and soon afterwards, Lawrence also introduced his friend, Ronald Campbell Gunn, to plant collecting. Shipments of specimens (of lichens and higher plants) from Lawrence and Gunn were to prove invaluable to botanists in England whose studies of the Australian flora relied completely on the receipt of adequate material from the colonies. With the tragic death of Lawrence in 1833, Gunn became Hooker's most important correspondent in Tasmania.

In 1840, Hooker's son, Joseph Dalton Hooker, arrived in Tasmania with an expedition commanded by Sir James Clarke Ross in the ships "Erebus" and "Terror". Although Joseph Hooker was employed as assistant surgeon aboard the "Erebus", he was also an adept botanist, as was David Lyall, his counterpart on the "Terror". The main aim of the voyage was to study terrestrial magnetism but, due to the expertise of these two members of the crew, the greatest contributions were in natural history. During two separate periods of three months in Tasmania, the botanists made their acquaintance of Gunn and collected in many areas of the island. The expedition remained in southern waters for three years (between 1839 and 1842) and visited Tasmania, New Zealand, Antarctica, the subantarctic islands and southernmost South America. An enormous collection, consisting of marine animals as well as plants, was amassed in that time. Largely at the insistence of his father, Joseph Hooker embarked on the ambitious project of writing an account of the botany of the regions he visited.

For the study of the lichens, Hooker gained the assistance of Thomas Taylor, Professor of Botany at Cork and an expert on lichens, mosses and liverworts. In 1844, they published a catalogue of 151 lichens collected on the voyage. Fifty-four of these were new species, eleven from Tasmania (Hooker & Taylor 1844). In the same year, the first part of J.D. Hooker's Botany of the Antarctic Voyage (i.e. Flora Antarctica, Vol. 1) was published, also containing a section on lichens by Taylor and Hooker. Taylor published additional contributions alone (Taylor 1844, 1847), including three new Tasmanian species originally collected by Lawrence. With the death of Taylor in 1848, studies on the lichens from the voyage were continued by the Reverend Churchill Babington.

1860 saw the publication of Flora Tasmaniae, the third part of J.D. Hooker's Botany of the Antarctic Voyage and a landmark in the history of Tasmanian botany. This work, dealing with angiosperms, gymnosperms, pteridophytes, bryophytes, algae, lichens and fungi, was

the first attempt to document the total flora of Tasmania, a feat which has never since been repeated despite subsequent revisions of selected plant groups. The lichen section was written by Babington, assisted by the bryologist, William Mitten, who collaborated in the account of the crustose species (Babington & Mitten 1860). Ninety-three lichens were enumerated, two of which, Sticta cetrarioides (= Heterodea muelleri (Hampe) Nyl.) and Baeomyces heteromorphus Nyl., were described as new. Specimens from a variety of sources were acknowledged. These included the collections of Lawrence and Gunn as well as the vast herbarium amassed by Hooker and Lyall on the Antarctic voyage. In addition, specimens were obtained from the Tasmanian architect, painter and plant collector, William Archer, from the professional collector, Samuel Mossman, and from the herbarium of Alan Cunningham. Further specimens had been provided by Ferdinand von Mueller, a German emigrant who worked in Adelaide as a pharmacist. His chief interest was botany and he corresponded with William Hooker as well as with numerous other botanists, both abroad and in the Australian colonies. His sources of Tasmanian plants included Charles Stuart and Augustus Oldfield, and the lichens from these collections were placed at the disposal of Babington and Mitten for the Flora.

Although Hooker's Antarctic voyage ranks supreme in terms of the botanical exploration of the southern zone, it was by no means a unique venture. A similar expedition was undertaken almost simultaneously (1837-1840) by the French under the command of Dumont D'Urville. The voyage parallels that of Hooker, particularly in its study of terrestrial magnetism. Botanical collections were undertaken by Hombron, the surgeon, Jacquinot, the second-in-command, and by D'Urville himself. The botanical results of the expedition were published by Hombron and Jacquinot in 1845. The cryptogamic plants were studied by the French lichenologist, Camille Montagne. His account of the lichens (Montagne 1845) lists species from the Pacific, the Straits of Magellan and New Zealand, as well as two species from Tasmania, Usnea florida and Cladonia furcata var. pungens, collected at Hobart by Hombron. Montagne's work also contains one of the earliest accounts of the similarities in the lichen floras of the northern and southern circumpolar regions.

## 3. The late Nineteenth Century

By the middle of the 19th Century, a core of enthusiastic naturalists was active in Tasmania, encouraged by the personal visits of Joseph Hooker (in 1840-42) and the renowned phycologist, William Harvey (in 1855). Ferdinand von Mueller, now based in Melbourne, had emerged as one of Australia's most accomplished botanists and had established a large network of collectors. In Tasmania, Charles Stuart remained von Mueller's most active lichen collector and many of Stuart's lichens were forwarded to Dr. E. Hampe in Germany. Hampe published a catalogue containing 36 Tasmanian lichens (Hampe 1852) including two new species, Lecidea stuartii and Biatora byssacea. Von Mueller received other Tasmanian lichens from T.A. and B. Gulliver, Skelton Emmett, Ambrose Neale and Dr. George Fordyce Story. These collections were sent to Anton von Krempelhuber in Munich (Krempelhuber 1881). Through his experience with Australian material, Krempelhuber was able to assist von Mueller in compiling a list of lichens for his Fragmenta Phytographiae Australiae (published from 1858 to 1881) (Krempelhuber 1880).

Much of the nomenclature of Australasian lichens was revised by Dr. Jean Müller Argoviensis in Geneva in a series of publications dating from about 1878. This work included Tasmanian lichens from many earlier collections (Müller Arg. 1882a, 1882b, 1883, 1889) as well as a revision of Krempelhuber's work (Müller Arg. 1887). Müller Argoviensis also corresponded with Ferdinand von Mueller from whom he received lichens that included occasional specimens from Tasmania collected by von Mueller himself. Additional studies on Tasmania's lichen flora were undertaken by Dr. James Stirton in Scotland who received specimens from many parts of the world. The majority of his Tasmanian lichens were collected by Hugh Paton and the local plant collectors, Walter Campbell, Mrs Heywood McEwen and E. Spong. Stirton described eight new species from Tasmania (Stirton 1876, 1882, 1898, 1900).

Up to this point, the history of Tasmanian lichenology entailed the export of specimens for study by overseas experts. Local interest and expertise with cryptogams was slow to develop and the years following the publication of Hooker's Flora Tasmaniae saw a gradual decline of interest in lichenology in Tasmania. However, in 1884, the Royal Society of Tasmania gained three new members, all of whom were to make a significant contribution to bryology and/or lichenology.

They were Richard Austin Bastow, William Anderson Weymouth and Leonard Rodway. Nevertheless, none were to actually publish any lichenological works relevant to Tasmania.

Bastow arrived in Tasmania in 1884 from Manchester. He studied both lichens and bryophytes and collected throughout Tasmania. He was also a qualified architect and soon put his skills to use in illustrating his publications with excellent line drawings. Unfortunately, his published works did not extend to Tasmanian lichens. Although he was a true pioneer in developing a local lichenological following in Tasmania, he is best remembered today for his accounts of the mosses, liverworts and algae. In 1888, he moved to Melbourne where his attention turned to the Victorian flora.

Weymouth was a second generation Tasmanian who lived in Hobart. He collected bryophytes and lichens as a hobby and corresponded with and sent specimens to numerous overseas experts. A catalogue of sixty-three lichens collected by him was published in Italy by Jatta. Ten new species, including Ochrolechia weymouthii, and three new varieties were described (Jatta 1910). Like Bastow, Weymouth's greatest contribution to Tasmanian botany was in the field of bryology. Although he was working towards a bryophyte flora of Tasmania, the final work was undertaken by Leonard Rodway in 1912. Rodway became the greatest Tasmanian botanist of his time and author of more than fifty works, including the Flora of Tasmania in 1903. Although he made occasional collections of lichens (Cheel 1912, 1914) they proved to be one of the few plant groups he did not study in detail.

Despite the large collection of lichens amassed by Bastow and Weymouth, it was left to mainland lichenologists during this time to make the most important contributions to Tasmanian lichenology. The Reverend Francis Robert Muter Wilson, a Presbyterian minister in Melbourne, was Australia's most productive lichenologist. He maintained active correspondence with European specialists such as Müller Argoviensis but he also published much of his own work. In the early 1890's, he visited Tasmania to collect lichens and make his acquaintance with local Tasmanian naturalists, notably Weymouth and Augustus Simson, the founder and secretary of the Northern Tasmanian Natural Science Association.

In 1893, Wilson published a list of 151 Tasmanian lichens, based on his own collections and those of a number of Tasmanian naturalists - R. Bastow, W.A. Weymouth and A. Simson as well as

Morton Allport, Miss Lilley and Mr. Coates (Wilson 1893). In addition he acknowledged a single specimen collected by Jules P. Verreaux who had visited Tasmania between 1842 and 1847 as a collector for the Museum of Natural History in Paris. Wilson updated much of the earlier work on Tasmanian lichens and included brief descriptions of all the species. His paper remains the most comprehensive single account of the Tasmanian lichen flora to this day.

Another prominent mainland lichenologist was John Shirley, a teacher and school inspector in Queensland, who published his Lichen Flora of Queensland in 1888-89. He visited Tasmania in 1892 for a meeting of the Australasian Association for the Advancement of Science. Here he met Weymouth who had presented a paper on the bryophytes of Tasmania to the meeting and who gave him a selection of lichen specimens from his herbarium. Shirley's first contribution to Tasmanian lichenology was a catalogue of 158 species based on virtually all of the literature published up to that time (Shirley 1893). The following year he produced a list of 55 additional lichens based on his own and Weymouth's collections (Shirley 1894). Seven new species were described, including Patellaria (=Bacidia) weymouthii. With this paper, Shirley's contributions to Tasmanian lichenology ceased. However, in 1912, he gained a DSc. from the University of Sydney for a thesis entitled. 'The thallus of the genus Parmelia', a work which was subsequently published in Tasmania by the Royal Society (Shirley 1918).

## 4. The early Twentieth Century

The beginning of the 20th Century saw the death of Wilson (in 1903) and the subsequent decline of lichenology both in Tasmania and Australia. Australian lichenology as a whole sustained a great tragedy with the loss of a crate of Wilson's type specimens en route to Italy in 1907 (see Filson 1976). In Tasmania, the void left by Bastow and Weymouth remained unfilled. Occasional isolated gatherings were made by a number of collectors (Gustav Weindorfer, Lillian Gibbs and F.E. Burbury) but no systematic study of the group was undertaken. A brief period of activity centred around Edwin Cheel in Sydney who became Curator at the National Herbarium there in 1924. Many Tasmanian specimens (including some collected by A.H.S. Lucas, J.H. Maiden and C.L. Atkinson) are cited in his chiefly bibliographic

publications (Cheel 1912, 1914). Nevertheless, this period saw a general loss of interest in lichenology, even on a world-wide scale.

**The present state of knowledge**

The revival of lichenology in the Northern Hemisphere in the late 1950's and 1960's soon saw a renewal of interest in the Australian flora. The late Geoffrey Bratt became a keen collector in Tasmania, largely as a result of his earlier travels in Patagonia. His collection of c. 15,000 specimens is housed in the Tasmanian Government Herbarium (HO). In 1963, Wetmore published a catalogue of Tasmanian lichens, citing all the published records of Tasmanian species (Wetmore 1963). These were essentially 19th Century records and amounted to 421 species in 82 genera. A directory of collectors and the location of their herbaria was also included, but no critical taxonomic evaluation of the species was attempted. A similar work on the lichens of the Australian mainland was later produced by Weber and Wetmore (1972).

Since then, updated accounts of some genera have been produced for the Australian region, superseding their treatment in Wetmore (1963) and thus hastening the need for a new checklist. These genera include Cladia (Filson 1981), Haematomma (Rogers 1982), Heterodea (Blackman et al. 1973, Filson 1978), Hypogymnia (Elix 1979), Knightiella (Galloway and Elix 1980) Parmelia (Filson 1982, Galloway and Elix 1983, 1984), Rinodina (Mayrhofer 1984), Teloschistes and Xanthoria (Filson 1969) and Umbilicaria (Blackman et al. 1974).

Studies on the New Zealand lichen flora have also had a profound influence on Tasmanian lichenology in revising the taxonomy of many genera which are also important in Tasmania. This work includes the pioneer studies of H.H. Allan, W. Martin and J. Murray (see Galloway 1974) as well as more recent studies, e.g. Baeomyces (Galloway 1980a), Coccocarpia (Arvidsson and Galloway 1979), the Graphidaceae (Hayward 1977), Lobaria (Galloway 1981), Pseudocyphellaria (Galloway 1983a, Galloway and James 1977,1980, Galloway et al. 1983, Wilkins and James 1979), Rinodina (Mayrhofer 1983), Stereocaulon (Galloway 1980b), Thysanothecium (Galloway and Bartlett 1982) and Xanthoparmelia (Galloway 1980c). The recently published Flora of New Zealand lichens (Galloway 1985) is of particular relevance to Tasmania and will greatly promote lichenology in the whole of the temperate Southern Hemisphere.

Collections from Tasmania have also figured in several recent world monographs, e.g. Cetraria (Kärnefelt 1979), Chrysothrix (Laundon 1981), Cladina (Ahti 1961), Coccocarpia (Arvidsson 1982), Collema (Degelius 1974), Degelia (Arvidsson and Galloway 1981), the Megalosporaceae (Sipman 1983), Parmelia (Esslinger 1977), Pseudoparmelia (Hale 1976a), Psoromidium (Galloway and James 1985), Relicina (Hale 1975b) and Sphaerophorus (Ohlsson 1974), as well as in the studies on Alectoria (Hawksworth 1972), Cladina (Ahti 1984), Cladonia (Ahti 1980) and Gymnoderma (Yoshimura 1973). This has occurred mainly through the review of existing 19th Century collections as well as through the dissemination of more recent collections. For example, frequent visits by Northern Hemisphere lichenologists in the last five years have also led to the wide distribution of Tasmanian material. Furthermore, the present project involved the sending of considerable numbers of Tasmanian specimens to specialists for determination and comment.

New species from Tasmania have been published in the genera Cladonia (Archer 1982, 1984, 1985), Lichina (Henssen 1969), Parmelia (Elix 1981a, 1981b, Filson 1984), Psoroma (James and Henssen 1975), Roccellinastrum (Henssen et al. 1982) and Stereocaulon (Galloway et al. 1976) whilst the new Tasmanian genera Conotremopsis and Wawea have been published by Vězda (1977) and Henssen and Kantvilas (1985) respectively. Additional new species from New Zealand (Galloway 1983b, Martin 1962) also have particular relevance to Tasmania, as do the new species from Australia published by Archer (1980), Elix and Stevens (1979) and Elix and Armstrong (1983). New records of Tasmanian lichens are given by Bratt and Cashin (1975, 1976), Filson and Rogers (1979), Elix and Streimann (1982), Kantvilas et al. (1985) as well as in this thesis.

The upsurge of interest in lichens in Australia is reflected in the existence of an active Australasian Association for Lichenology (formed in 1974), the publication of two handbooks on the flora (Filson and Rogers 1979, Rogers 1981) and, more recently, a revised checklist of Australian lichens (Filson 1983). However, despite this recent proliferation of publications on selected Australasian lichens, no completed flora is available at present, not even for the macrolichens. The intention of the Flora of Australia Project to commit four volumes to the lichens promises a bright future for this previously much-neglected branch of botany.

**Purpose of the present study**

In the preceding sections, the current state of lichenology in Tasmania has been placed into perspective against its historical background. In summary, previous studies have consisted of two periods. The first comprises the 19th Century and features the initial discovery and description of much of the flora. The second period consists of the last two decades and features a relearning of the knowledge gained by the early lichenologists and a reappraisal of that knowledge in terms of modern taxonomic principles. The fact that the great emphasis of lichenology has been taxonomic is simply a reflection of the "state of the art". Other fields of research, particularly ecology, depend principally on a good understanding of the species involved.

This present work is directed towards an examination of the lichen flora in Tasmania's cool temperate rainforest. Studies on the lichens of cool temperate rainforest are very rare, even on a global scale. Mark et al. (1964) briefly noted some aspects of the lichen flora at one forest community in New Zealand, whilst Rundel (1980) briefly described some epiphytic communities in Chile. Ashton and McRae (1970) discussed the vertical zonation of some lichen species in rainforest in Victoria. Before the present study commenced, work directed specifically towards Tasmanian rainforest lichens was almost non-existent and consisted of incomplete species lists (Bratt 1976, 1978), and the physiological investigation of two species by Rundel et al. (1979). Thus the composition and character of the lichen flora in rainforest (or indeed in any of Tasmania's vegetation) was unknown and the need to establish a basic floristic and ecological framework was clearly evident. Such an investigation has been undertaken here. The results provide a base for more specialised studies, some of which have also been tackled, including the documentation of changes in the lichen flora in relation to habitat changes and the description of some common lichen communities.

## B. THE STUDY AREA

### Tasmania: physiography, climate and vegetation

Tasmania is an island extending from 40°38' to 43 39' South and 144°36' to 148°23' East. It lies in the Southern Ocean, about 240 km south of the south-eastern corner of the Australian mainland. The area of the island is approximately 68,000 sq. km and is roughly comparable to that of the island of Ceylon or the Republic of Ireland. Tasmania's topography is extremely rugged, but the most distinctive feature of its mountains is not their height (the highest peak is 1617 m) but their abundance. The mountains are concentrated mainly in the western half of the island and in the North-East (Anonymous 1976). The island consists of two major land-form provinces. The western half is comprised of intensely folded Precambrian and Cambrian sediments whilst the eastern half consists largely of extensively faulted Permian and Triassic sediments capped with Jurassic dolerite (Jackson 1981).

Tasmania's climate is essentially temperate marine although the island is large enough to reveal some distinct continental characteristics (Langford 1965). Whilst the maximum summer and minimum winter recorded temperatures are 41°C and -12°C respectively, such extremes are rare and are restricted to only a few days of the year. The combination of mountainous terrain in the western half of the state and the prevailing westerly winds produce a marked west-east variation in climate, particularly with regard to rainfall. Thus western Tasmania receives annual rainfalls of between 1300 and 3600 mm whilst parts of the East receive as little as 500 mm (Anonymous 1976).

General accounts of Tasmania's vegetation have been given by several authors including Curtis and Somerville (1949) and Jackson (1965). A mosaic of vegetation types are present. The main formations are austral montane, temperate rainforest and sclerophyll forest. However, many ecotonal forms exist due to the effects of fire and edaphic factors superimposed upon the more general effects of climate and topography (Jackson 1965). Fire is particularly important and many individual species and plant communities, especially in drier areas, depend on it for their survival.

Austral montane vegetation consists essentially of high altitude non-forest communities dominated by shrubs and herbs including sedges. Rainforest occurs across a range of altitudes and mainly includes forests where Nothofagus is an important component (see p.13 for further discussion). The plants of these two formations essentially belong to a Southern Oceanic component in the Tasmanian flora, with affinities to New Zealand and southern South America.

Sclerophyll forest is dominated by the genus Eucalyptus and has its closest phytogeographic affinities to the vegetation of mainland Australia. It consists of two main types: dry sclerophyll and wet sclerophyll. In the former, there is an understorey of low shrubs (particularly Epacridaceae and Leguminosae) and scattered small trees from such genera as Banksia, Casuarina and Exocarpos. In wet sclerophyll forest, the understorey consists of a dense layer of tall shrubs of Pomaderris, Olearia, Bedfordia, Phebalium and other species. As rainfall increases and fire frequency decreases, an increasing number of species from rainforest become present in the understorey. The ecotone between rainforest and wet sclerophyll forest is known as "mixed forest" (Gilbert 1959) and, at its best development, features eucalypts emergent over a closed rainforest understorey. The ecotone is maintained by fire which must occur within the life span of the eucalypts (c. 350 years) (Jackson 1968).

Other major vegetation types which do not easily fit any of the above categories include coastal heath and sedgeland-heath. These are maintained by a combination of fire and edaphic factors (Jackson 1965). The latter covers vast areas of south-western and western Tasmania and forms complex mosaics with sclerophyll and rainforest vegetation.

Tasmania's flora consists of approximately 1300 vascular species, of which c. 20% are endemic (Nelson 1981). Endemism is concentrated in alpine and rainforest vegetation. The largest or most conspicuous families include the Compositae, Leguminosae, Myrtaceae, Epacridaceae and Proteaceae. There are only eleven conifer species, eight of which are endemic, including three endemic genera. The Pteridophyte flora consists of approximately 90 species, of which only two are endemic.

**Vegetation studied : cool temperate rainforest in Tasmania**

Cool temperate rainforest is restricted to the Southern Hemisphere where it occurs only in Australia, New Zealand and southern South America. Within Australia, it attains its greatest extent and diversity in Tasmania, with only a few outlying populations occurring on the mainland. It is thought to be ancient, resembling parts of an early flora which occurred on the supercontinent of Gondwanaland prior to its breakup (Barlow 1981).

Tasmania's rainforest has been recently surveyed and classified by Jarman, Brown and Kantvilas (1984) and much of the information included here is derived from that work. It has been defined as forest vegetation greater than 8 m tall, dominated by species of Nothofagus, Eucryphia, Atherosperma, Athrotaxis, Lagarostrobos, Phyllocladus and/or Diselma. Some of the more common understorey species include members of the Compositae (Olearia), Cunoniaceae (Anodopetalum), Elaeocarpaceae (Aristotelia), Epacridaceae (Archeria, Prionotes, Richea, Trochocarpa), Escalloniaceae (Anopterus), Proteaceae (Agastachys, Cenarrhenes, Orites, Telopea), Rubiaceae (Coprosma), Rutaceae (Acradenia) and Winteraceae (Tasmannia) (Jarman and Brown 1983).

Unlike many other Tasmanian vegetation types which depend on fire for their continuance, rainforest is capable of regeneration in the absence of large-scale disturbance (Jarman and Brown op. cit.). Its climatic requirements are c. 1000 mm of rainfall per annum, with a minimum of 25 mm per month, although within this regime it is often displaced by other vegetation through the effects of fire (Jackson 1968). The distribution of rainforest in Tasmania is shown in Figure 1. The most extensive areas occur in the North-West, with increasingly fragmented occurrences in the West, South-West, South and in elevated situations in the North-East. Small, isolated stands, presumably relict in nature, occur in the South-East and East.

The most common growth forms present in Tasmanian rainforest are trees, shrubs, ferns, bryophytes and lichens. Grasses are uncommon whilst sedges and other graminoids may be locally abundant but mostly inconspicuous. Lianes are virtually absent and only one epiphytic angiosperm (Prionotes) is present. However, epiphytic ferns, bryophytes and lichens are very common. Tree heights are generally less than 30 m except on particularly

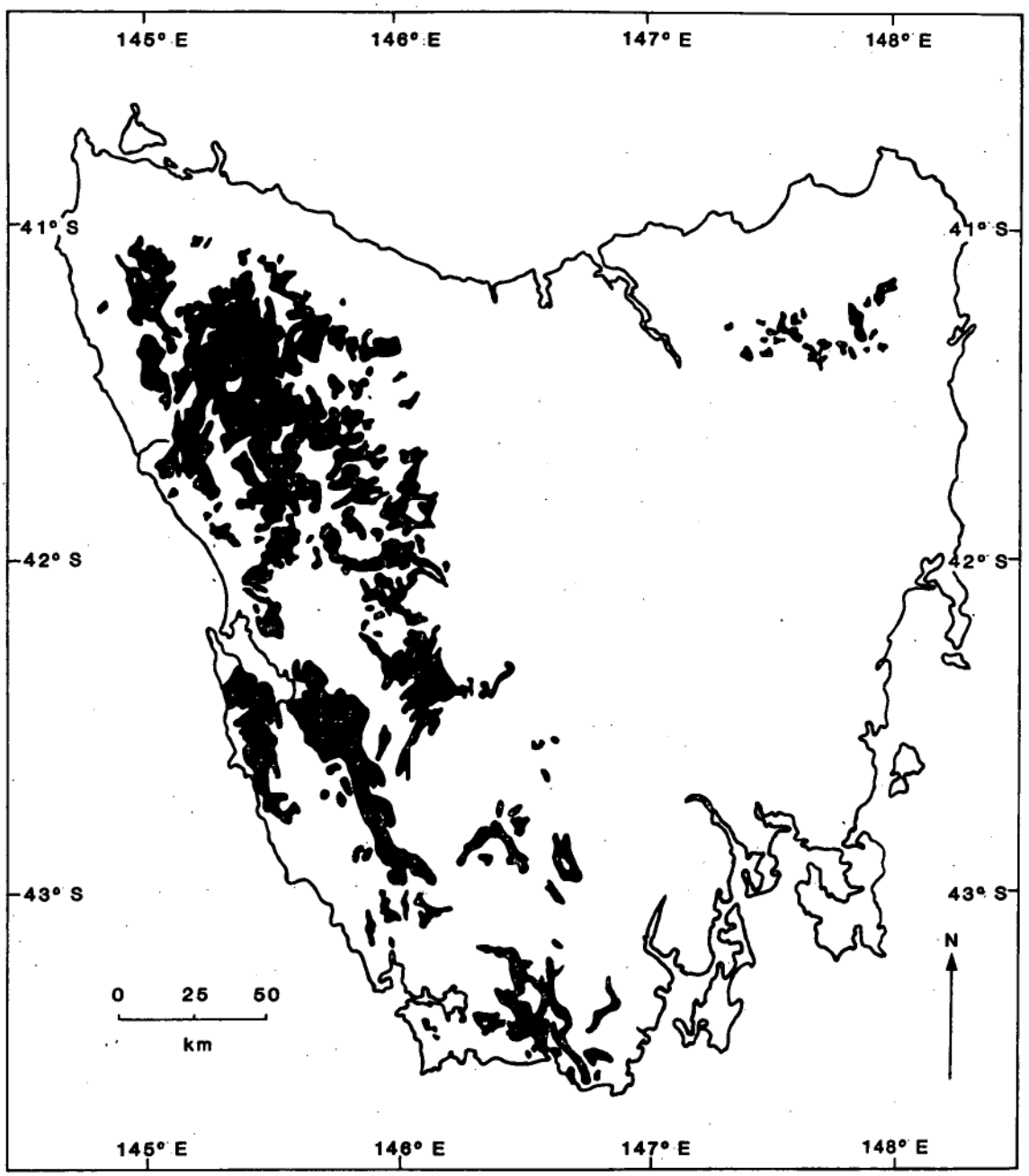


Figure 1. Distribution of rainforest in Tasmania (after Kirkpatrick and Dickinson 1984).

favourable sites. With the exception of Nothofagus gunnii, all woody species are evergreen.

Angiosperms recorded in rainforest are represented by approximately 80 species, in 30 families of Dicotyledons and six families of Monocotyledons. The most important families with respect to prominent and/or widespread species are the Fagaceae, Atherospermataceae, Eucryphiaceae, Myrtaceae, Cunoniaceae, Escalloniaceae, Proteaceae, Epacridaceae, Winteraceae and Cyperaceae. The Epacridaceae is by far the richest family with about 17 species in eight genera. Nothofagus cunninghamii (Fagaceae) is the most widespread species and is the dominant tree in many communities. Eight conifers in three families occur in rainforest. Forty-eight Pteridophytes, including two Psilopsids (Tmesipteris), two Lycopsids and 44 ferns are also present. The most diverse fern families are the Blechnaceae and Hymenophyllaceae. Approximately 150 species of bryophytes have also been recorded from rainforest. Three quarters of the angiosperms and all but one of the conifers are endemic to Tasmania but endemism is negligible in the other groups.

Rainforest has been classified into four groups on the basis of floristics and structure (Jarman et al. 1984). The first group is termed callidendrous rainforest and is characterised by park-like communities with open understoreys and tall, well-formed trees. Nothofagus cunninghamii is dominant with Atherosperma moschatum subdominant. The diversity of phanerogams is low and undershrubs are scattered and inconspicuous. However, epiphytic and ground ferns are very well-developed and feature, amongst others, the tree fern, Dicksonia antarctica, and the ground fern, Polystichum proliferum.

The second group is termed thamnic rainforest, the name deriving from the presence of a well-developed shrubby understorey. Nothofagus cunninghamii is dominant with Eucryphia lucida, Lagarostrobos franklinii, Athrotaxis selaginoides and/or Phyllocladus aspleniifolius subdominant or co-dominant. The most common shrub species include Anodopetalum biglandulosum, Anopterus glandulosus, Cenarrhenes nitida, Richea pandanifolia and species of Archeria and Trochocarpa. Ferns are less well-developed than in callidendrous forest with tree ferns rare or absent. However, the ground fern, Blechnum wattsii, may be very prolific. At higher altitudes (above c. 750 m), callidendrous and thamnic forests become reduced in height

and converge in structure. There is also a marked decline in the diversity of ferns with increasing altitude.

The third rainforest group is known as implicate rainforest due to the densely tangled understorey of interwoven stems. The forests are lower (often less than 20 m), with broken canopies which are usually more or less continuous with the understorey. The diversity and number of individuals of woody angiosperms is significantly greater than in the preceding groups. Dominance is shared amongst several species which may include Nothofagus cunninghamii, N. gunnii, Lagarostrobos franklinii, Phyllocladus aspleniifolius, Athrotaxis selaginoides, Diselma archeri, Eucryphia lucida, E. milliganii as well as a number of myrtaceous species (chiefly Leptospermum spp). Understorey shrubs include Agastachys odorata, Anodopetalum biglandulosum, Anopterus glandulosus, Cenarrhenes nitida, Coprosma nitida, Cyathodes juniperina, Monotoca submutica, Prionotes cerinthoides and many others. Ferns are usually poorly developed.

The remaining rainforest group is open montane forest. It is dominated by Athrotaxis cupressoides and is confined to high altitudes. Trees are commonly less than 15 m tall and widely spaced. The understorey varies from a tall dense shrubbery to a low heath. The main undershrubs include Nothofagus gunnii, low conifers or species from the Myrtaceae, Proteaceae and Epacridaceae. Ferns are poorly developed in this group.

# II FLORISTICS

# A. TASMANIAN RAINFOREST LICHENS

The data presented below is derived from a general survey of rainforest throughout Tasmania and from systematic sampling in some selected areas which were the subject of detailed ecological studies (see part III). The general survey involved an examination of all the higher plant communities described from rainforest (see Jarman et al. 1984) across a wide range of geographical, altitudinal and topographical situations (although open montane forests were undersampled). Supplementary floristic data from other vegetation types in Tasmania provided a general overview for the whole project and enabled the rainforest lichen flora to be placed into perspective within the Tasmanian lichen flora as a whole.

## Lichen species found in rainforest

Two hundred and eight lichens have been recorded from rainforest and are listed in Table 1. This inventory is arranged after the classification system of Poelt and Vězda (1981) for European lichens. Genera not included by these authors, i.e. not occurring in Europe, are classified after Poelt (1973) and other sources. Thus Megalosporaceae, Hypogymniaceae and Cladiaceae are recognised as separate families after Sipman (1983), Elix (1979) and Filson (1981) respectively. Usneaceae is segregated from Parmeliaceae (Poelt 1973), Wawea is placed in the Arctomiaceae (Henssen and Kantvilas 1985), Conotremopsis in the Ostropaceae (Vězda 1977) and Roccellinastrum in the Lecideaceae (Henssen et al. 1982), whilst the Pannariaceae includes Leioderma, Degelia and Psoromidium after Jørgensen (1978), Arvidsson and Galloway (1981) and Galloway and James (1985) respectively. Bactrospora has been ascribed to the Opegraphaceae and Dendriscocaulon is tentatively placed in the Peltigeraceae although Galloway (1985) suggests it might be better accomodated in the Lobariaceae. The concept of the Lecideaceae and Lecanoraceae as diverse, unnatural aggregations (after Poelt and Vězda 1981) is preferred over the recent revision of these families by Hafellner (1984), at least until the status of several poorly known Tasmanian taxa can be clarified. One rainforest species (Dictyonema) is a basidiolichen whilst the remainder are ascolichens or lichenes imperfecti.

Table 1: Lichens recorded in cool temperate rainforest in Tasmania. The arrangement of genera follows Poelt and Vezda (1981) with some minor rearrangements (see text, p. 17).

**ASCOMYCETES**

I CALICIALES

CALICIACEAE:

Chaenotheca brunneola (Ach.) Müll. Arg.
Coniocybe furfuracea (L.) Ach.

SPHAEROPHORACEAE:

Sphaerophorus insignis Laurer
S. ligulatus G. Kantvilas in ed.
S. macrocarpus Ohlsson in D. Galloway
S. melanocarpus (Sw.) DC.
S. murrayi Ohlsson in Tibell
S. patagonicus (Dodge) Ohlsson in D. Galloway
S. ramulifer Lamb
S. scrobiculatus (Church. Bab.) Sato
S. tener Laurer

II LECANORALES

MICAREACEAE:

Micarea mutabilis B. Coppins in ed.
M. prasina Fr. aggr.
Scoliciosporum cf. pruinosum (P. James) Vězda

LECIDEACEAE s. lat.:

Bacidia buchananii (Stirton) Hellbom
B. weymouthii (Shirley) Zahlbr.
Bacidia sp. 1
Bacidia sp. 2
Catillaria kelica (Stirton) Zahlbr.
Catillaria sp. 1
Catillaria sp. 2
Catillaria sp. 3
Catillaria sp. 4
Catinaria sp.
C. pulverea (Borrer) Vězda & Poelt
Cliostomum griffithii (Sm.) Coppins
Fuscidea sp.
Lecidea ceroplasta (Church. Bab.) J.D. Hook.
L. cf. granulosa (Hoffm.) Ach.
L. laeta Stirton
Lecidea sp. 1

cont.

Table 1: cont.

Lecidea sp. 2
Lecidea sp. 3
Lecidea sp. 4
Lecidella elaeochroma (Ach.) Choisy aggr.
Lopadium sp.
L. disciforme (Flotow) Poelt & Vězda
Megalaria grossa (Pers. ex Nyl.) Hafellner
Mycoblastus sp. 1
Mycoblastus sp. 2
Phyllopsora congregans (Zahlbr.) D. Galloway
Psilolechia lucida (Ach.) Choisy
Roccellinastrum neglectum Henssen & Vobis
unknown sp. B

MEGALOSPORACEAE:
Austroblastenia pauciseptata (Shirley) Sipman
Megaloblastenia marginiflexa (J.D. Hook. & Taylor) Sipman
Megalospora campylospora (Stirton) Sipman
M. lopadioides Sipman
M. subtuberculosa (Knight) Sipman

LECANORACEAE:
Haematomma infuscum (Stirton ex Bailey) R.W. Rogers
Lecanora sp.
L. atra (Huds.) Ach.

BAEOMYCETACEAE:
Baeomyces fungoides (Sw.) Ach.
B. heteromorphus Nyl. ex Church. Bab. & Mitten

CLADONIACEAE:
Cladina confusa (R. Sant.) Follm. & Ahti
Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel aggr.
C. ochrochlora Flörke
C. scabriuscula (Delise) Leighton
C. squamosula Müll. Arg.
C. subdigitata Nyl.
Gymnoderma melacarpum (F. Wilson) Yoshim.

CLADIACEAE
Cladia aggregata (Sw.) Nyl.
C. schizopora (Nyl.) Nyl.

SIPHULACEAE:
Siphula sp.
S. cf. dissoluta Nyl.

cont.

Table 1: cont.

STEREOCAULACEAE:

Pilophorus conglomeratus F. Wilson

Stereocaulon ramulosum (Sw.) Räuschel

PARMELIACEAE:

Cetraria chlorophylla (Willd.) Vainio

Pannoparmelia angustata (Pers. in Gaud.) Zahlbr.

Parmelia cunninghamii Crombie

P. labrosa Zahlbr.

P. perlata (Huds.) Ach.

P. protosulcata Hale

P. pruinata Müll. Arg.

P. cf. revoluta Flörke

P. sinuosa (Sm.) Ach.

P. subfatiscens Kurok.

P. subglabra (Räs.) Essl.

P. tenuirima J.D. Hook. & Taylor

P. testacea Stirton

USNEACEAE:

Usnea sp.

U. arida Mot.

U. capillacea Mot.

U. molliuscula Stirton

U. rubicunda Stirton

HYPOGYMNIACEAE:

Hypogymnia lugubris (Pers.) Krog

H. mundata (Nyl.)Rassad.

H. subphysodes (Kremp.) Filson

H. turgidula (Bitter) Elix

Menegazzia bullata (Stirton) Bitter

M. caliginosa P. James & D. Galloway

M. eperforata P. James & D. Galloway

M. globulifera R. Sant.

M. inactiva P. James in ed.

M. minuta P. James in ed.

M. nothofagi (Zahlbr.) P. James & D. Galloway

M. platytrema (Müll. Arg.) R. Sant.

M. retipora (Stirton) Bitter

M. subbullata P. James in ed.

M. subpertusa P. James & D. Galloway

M. testacea P. James & D. Galloway

M. ultralucens P. James & D. Galloway

M. weindorferi (Zahlbr.) R. Sant.

cont.

Table 1: cont.

PHYSCIACEAE:

Heterodermia microphylla (Kurok.) Swinsc. & Krog
Rinodina dissa (Stirton) Mayrhofer

TRAPELIACEAE:

Placopsis gelida (L.) Lindsay

PERTUSARIACEAE:

Coccotrema cucurbitula (Mont.) Müll. Arg.
Ochrolechia sp.
Pertusaria cf. nothofagi Zahlbr.
P. cf. novaezelandiae Szatala
Pertusaria sp. 1
Pertusaria sp. 2

PHLYCTIDACEAE:

Phlyctella subuncinata (Stirton) D. Galloway

ARCTOMIACEAE:

Wawea fruticulosa Henssen & Kantvilas

COLLEMATACEAE:

Collema fasciculare (L.) Wigg.
C. glaucophthalmum Nyl.
C. laeve J.D. Hook. & Taylor
C. leucocarpum J.D. Hook. & Taylor
C. subconveniens Nyl.
C. subflaccidum Degelius
Leptogium azureum (Sw.) Mont.
L. brebissonii Mont. in Webb & Berthelot
L. limbatum F. Wilson
L. victorianum F. Wilson
Physma sp.
P. chilense Hue
Ramalodium sp.

PANNARIACEAE:

Degelia durietzii Arvidsson & D. Galloway
D. gayana (Mont.) Arvidsson & D. Galloway
Leioderma amphibolum (Knight) P.M. Jørg. & D. Galloway in̆ed.
L. pycnophorum Nyl.
L. sorediatum P.M. Jørg. & D. Galloway in̆ed.
Pannaria sp.
P. immixta Nyl.
P. aff. pezizoides (G.H. Web.) Trevis.
Parmeliella nigrocincta (Mont.) Müll. Arg. aggr.

cont.

Table 1: cont.

Psoroma asperellum Nyl.
P. durietzii P. James & Henssen
P. euphyllum Nyl.
P. leprolomum (Nyl.) Räsänen
P. microphyllizans (Nyl.) D. Galloway
P. paleaceum (Fr.) Nyl.
P. pholidotoides (Nyl.) Trevis.
P. soccatum R. Br.
Psoroma sp. 1
Psoroma sp. 2
Psoroma sp. 3
Psoroma sp. 4
Psoromidium aleuroides (Stirton) D. Galloway
P. versicolor (J.D. Hook. & Taylor) D. Galloway

PELTIGERACEAE:

Dendriscocaulon dendriothamnodes Dughi in D. Galloway
Peltigera dolichorhiza (Nyl.) Nyl.
Polychidium sp.

NEPHROMATACEAE:

Nephroma australe Richard
N. cellulosum (Sm. in Ach.) Ach.

LOBARIACEAE:

Pseudocyphellaria ardesiaca D. Galloway
P. argyracea (Delise) Vainio aggr.
P. billardieri (Delise) Rasanen
P. colensoi (Church. Bab.) Vainio
P. coronata (Mull. Arg.) Malme
P. crocata (L.) Vainio
P. delisea (Fée) D. Galloway & P. James
P. dissimilis (Nyl.) D. Galloway & P. James
P. faveolata (Delise) Malme
P. granulata (Church. Bab.) Malme
P. cf. insculpta (Stiz.) D. Galloway in ed.
P. intricata (Delise) Vainio
P. rubella (J.D. Hook. & Taylor) D. Galloway & P. James
P. subvariabilis (Nyl.) Vainio
Sticta fuliginosa (Dicks.) Ach.
S. limbata (Sm.) Ach.
S. stipitata Knight
S. sublimbata (Steiner) Swinsc. & Krog

cont.

Table 1: cont.

III GYALECTALES

GYALECTACEAE:

Coenogonium implexum Nyl.

Dimerella lutea (Dicks.) Trevisan

IV OSTROPALES

OSTROPACEAE:

Conotremopsis weberiana Vězda

Ramonia muscicola Vězda in ed.

THELOTREMATACEAE:

"Asteristion" lamelliferum A. Vězda nom. provis.

Thelotrema decorticans Müll. Arg.

T. lepadinum (Ach.) Ach.

T. subdenticulatum (Zahlbr.) G. Salisb.

GRAPHIDACEAE:

Graphis insidiosa (Knight & Mitten) J.D. Hook.

G. scripta (L.) Ach.

Phaeographis exaltata (Mont. & v.d. Bosch) Müll. Arg.

V PYRENULALES

TRICHOTHELIACEAE:

Porina leptaleina (Nyl.) Müll. Arg.

PYRENULACEAE:

Pseudopyrenula galactina Shirley

Pyrenula sp.

cont.

Table 1: cont.

VI ARTHONIALES

ARTHONIACEAE:

Arthonia cinereopruinosa Schaer. s. lat.
Arthonia sp. 1
Arthonia sp. 2
Arthothelium sp. 1
A. ilicinum (Taylor) P. James
Arthothelium sp. 2

OPEGRAPHACEAE:

Bactrospora dryina (Ach.) Massal.
Bactrospora sp.
Chiodecton colensoi (Massal.) Müll. Arg.
Lecanactis abietina (Ach.) Körb.
L. subpremnea A. Vězda ad. interim
Lecanactis sp.
Opegrapha stellata Knight
Schismatomma sp.

ROCCELLACEAE:

Sagenidium molle Stirton

CHRYSOTHRICACEAE:

Chrysothrix candelaris (L.) Laundon

LICHENES IMPERFECTI

Lepraria incana (L.) Ach.
L. membranacea auct.
unknown sp. A
unknown sp. C

BASIDIOMYCETES

I PORIALES

CORTICIACEAE:

Dictyonema sericeum (Sw.) Berk.

The rainforest lichen flora comprises 128 macrolichens (35 fruticose, 76 foliose, 12 squamulose and 5 filamentous species) and 80 microlichens (66 crustose and 14 leprose species). The inventory of macrolichens is considered virtually complete and an identification key for the species is provided in part II B (p.32). Future additions are expected to be rare species or species from non-rainforest vegetation which may occasionally invade rainforest in locally favourable habitats (usually at the forest margins). The inventory of microlichens remains very incomplete and only the more common, better known or most easily recognisable species are included. With further work the number of microlichens can be expected to double at least. Brief descriptions of all species, as well as habitat and distribution data, are provided in Appendix 1.

The largest macrolichen families in rainforest are the Lobariaceae (Pseudocyphellaria, Sticta), Collemataceae (Collema, Leptogium, Ramalodium, Physma), Pannariaceae (Pannaria, Parmeliella, Leioderma, Degelia, Psoromidium, Psoroma), Sphaerophoraceae (Sphaerophorus), Hypogymniaceae (Hypogymnia, Menegazzia) and the Parmeliaceae (Parmelia, Pannoparmelia, Cetraria). Between them, these six families comprise 73% of the macrolichen flora and contain most of the dominant genera or species. 40 genera are represented. The largest are Menegazzia (14 species), Pseudocyphellaria (14 species), Psoroma (12 species), Parmelia s. lat. (11 species), Sphaerophorus (9 species) and Collema (6 species). However, neither Parmelia nor Collema are important components of the rainforest flora in terms of biomass or frequency and are mostly found at the forest margins.

Corresponding estimates for the microlichens are difficult to calculate due to the large number of unknown species and the uncertainty of their taxonomy, particularly at the family level. However, on the basis of the 80 species recorded, important groups with respect to diversity and/or common species are the Megalosporaceae (Austroblastenia, Megalospora, Megaloblastenia), Pertusariaceae (Coccotrema, Ochrolechia, Pertusaria), Arthoniaceae (Arthonia, Arthothelium) and Opegraphaceae (Bactrospora, Chiodecton, Lecanactis, Opegrapha, Schismatomma). 35% of the microlichens recorded belong to the Lecideaceae s. lat. but this is an unnatural unit which can be subdivided into several smaller, more natural families (Hafellner 1984). Major genera include Pertusaria (4 species) and Lecanactis, Thelotrema, Megalospora, Arthonia and

Arthothelium (3 species each). Many species are presently attributed to Lecidea, Catillaria and Bacidia but are likely to be placed elsewhere when their taxonomy becomes better understood.

Families which form an important component of the Tasmanian lichen flora as a whole but which are poorly represented in rainforest include the Cladoniaceae (7 species compared to 30-40 in sclerophyll vegetation), Physciaceae (one species each of Heterodermia and Rinodina), Teloschistaceae (absent) and Ramalinaceae (absent). The Parmeliaceae is also considerably more diverse in non-rainforest vegetation, particularly dry sclerophyll forest, where 30-40 species (mostly from subgen. Xanthoparmelia) are represented.

The majority of the lichens in rainforest are epiphytic and fewer than 3% are obligately saxicolous or terricolous species. Of the macrolichens, 27% have a blue-green photobiont but many of these, e.g. Collema, Leptogium and Sticta, are mostly marginal rainforest species. However, a further 21% of the flora, including the dominant rainforest genera Pseudocyphellaria and Psoroma, possess cephalodia. Thus 48% of the rainforest macrolichens are capable of nitrogen fixation and may well contribute significantly to the nitrogen budget of the rainforest ecosystem. Blue-green photobionts are absent in the microlichens with the exception of Coccotrema cucurbitula which has cephalodia.

**Phytogeography of the rainforest flora**

Most of the discussion in this section is based on to the macrolichens because the majority of regional and world taxonomic revisions have concentrated on this group. Known distributions of the rainforest species are given in Appendix 1 but these are often difficult to evaluate because of the incomplete nature of the data for many regions of the world. Although the data are scanty, it seems likely that the microlichens will reflect similar trends to those apparent in the macrolichens.

Approximately 60% of the Tasmanian rainforest lichen flora consists of species and genera which are confined to or centred in the south of the Southern Hemisphere: in Tasmania, New Zealand and southern South America. These have been ascribed to the "austral" (Galloway 1979) or the "austral cool temperate" (Jørgensen 1983) element. This element includes genera such as Menegazzia, Psoroma, Pseudocyphellaria, Sphaerophorus, Leioderma, Degelia, Sagenidium,

Wawea, Conotremopsis, Roccellinastrum, Psoromidium, Siphula, Austroblastenia and Megaloblastenia, all of which have few or no representatives in the Northern Hemisphere. Some wide-ranging genera have distinctly "austral" species, e.g. Physma chilense, Collema laeve, Hypogymnia lugubris, H. subphysodes and Nephroma cellulosum.

The composition of the rainforest lichen flora demonstrates an extremely close relationship between Tasmania and New Zealand, with 76% of the species being common to both regions. In contrast, only 56% of the species are shared with mainland Australia (mainly with Victoria). [These figures have been calculated after excluding the unidentified microlichens (28 species) from the total Tasmanian inventory.] In general, the diversity of the New Zealand flora is greater than that of Tasmania. For example, there are 42 species of Pseudocyphellaria and 13 species of Sticta in New Zealand (Galloway 1985) compared to 15 and 4 species respectively in Tasmania. Similarly the Sphaerophoraceae is represented by three genera in New Zealand but by only one in Tasmania, although most species of Sphaerophorus are common to both regions. However, these comparisons are based on the total floras. Although the data are not available, it would be interesting to compare the lichen floras from similar rainforest habitats in the two regions.

The distributions of austral cool temperate lichens occurring in Australasia (i.e. mainland Australia, Tasmania and New Zealand) tend to fall into three broad categories. The first of these consists of lichens endemic to New Zealand [see Galloway (1985) for examples]. The second includes species present in both New Zealand and Tasmania. In Tasmania, such species tend to be confined to rainforest where some, e.g. Sagenidium molle, Chiodecton colensoi, Lecidea ceroplasta and Leioderma amphibolum, are common and widespread. However, several others, e.g. Degelia durietzii, Megalospora subtuberculosa, Menegazzia caliginosa, M. ultralucens, Roccellinastrum neglectum and Pseudocyphellaria ardesiaca, are rare and often poorly developed. The last category consists of species present in New Zealand, Tasmania and South-East Australia, e.g. Nephroma australe, Pseudocyphellaria billardieri, P. colensoi and Psoroma microphyllizans. Such species are mostly common and ecologically wide-ranging in many high-rainfall habitats in Tasmania. From these groups, the general impression is that New Zealand is a centre of distribution for many austral cool temperate lichens. This flora extends into Tasmania and Australia but

has become fragmented, particularly in Australia. Exceptions to this pattern include a small number of rainforest lichens which are common (locally) in Tasmania but apparently rare in New Zealand, e.g. Wawea fruticulosa and Conotremopsis weberiana.

The similarities in the lichen floras of Tasmania and South America occur largely at the generic level (see Rundel 1980). Shared species are relatively few (c. 20%) and often exhibit asexual reproduction, e.g. Menegazzia globulifera, Pseudocyphellaria delisea, P. granulata, Parmelia cunninghamii, P. protosulcata, P. subglabra and Psoroma leprolomum [see also Arvidsson and Galloway (1981) and Galloway and James (1985)]. The wide distribution of these species is likely to be due to the effects of long distance dispersal of their asexual propagules (cf. Jørgensen 1983). However, several other species which are similarly common to all southern regions are obligately sexually reproducing and hence less likely to owe their wide distribution to long distance dispersal. These include Sphaerophorus spp., Collema laeve, Hypogymnia lugubris, Nephroma cellulosum, Psoromidium versicolor, Pseudocyphellaria faveolata and Degelia gayana. In addition, there are several pairs of obviously related species, e.g. Psoroma euphyllum (Tasmania - New Zealand) and P. calophyllum (South America), occurring in similar habitats in both regions [see Galloway (1979) for further examples].

The overall similarity between the floras of the south Southern Hemisphere has been explained by their earlier conjunction with Antarctica in the supercontinent of Gondwanaland 80 m years ago (Raven and Axelrod 1972). Fossil evidence indicates that Nothofagus was once widespread across Australasia, Antarctica and South America (van Steenis 1971), providing evidence for the notion that at least this part of Gondwanaland possessed closed forest akin to extant cool temperate rainforest (Barlow 1981), presumably with a lichen flora related to that occurring in such forests today. Arvidsson and Galloway (1981) suggest that the obligately sexually reproducing species which are shared by all southern regions (see above) could represent part of the primitive Gondwanan lichen flora. One explanation for the major differences in the lichen floras of Tasmania/New Zealand versus that of South America is that they represent two divergent arms of a common ancestral stock, most of which perished in the glaciation of Antarctica.

Other smaller phytogeographical elements in the rainforest lichen flora are an "austral warm temperate" (Jørgensen 1983) or "Australian" (Galloway 1979) element and a "cosmopolitan" element. Examples of rainforest species from the "Australian" element include Cladia spp., Collema leucocarpum, Gymnoderma melacarpum, Baeomyces heteromorphus, Lecidea laeta, Usnea arida and Parmelia pruinata. In Tasmania, this element is best developed in the drier, eucalypt-dominated eastern areas which in the past have seen frequent land connections with mainland Australia. The genera and species of this element tend to be centred in Australia and show some similarities to South Africa and India (Rogers 1977, Rogers and Stevens 1981). Both Tasmania and New Zealand are comparatively impoverished in this element and posses the more wide-ranging species (Galloway 1979), effectively the converse of the situation with the cool temperate taxa. The same dispersal route from Australia is probably also responsible for the occurrence in Tasmania of several pantropical species, e.g. Heterodermia microphylla, Dictyonema sericeum, Phaeographis exaltata and Collema glaucophthalmum.

In rainforest, many "Australian" lichens are associated with disturbance. For example, Gymnoderma melacarpum and Cladia schizopora are virtually obligate epiphytes of Eucalyptus, a transient component of rainforest. Species of Collema are usually confined to rainforest margins. Baeomyces heteromorphus is a species of disturbed earth whilst Parmelia pruinata and Lecidea laeta are extremely impoverished in comparison with their lush development in sclerophyll forest.

The cosmopolitan element contains those taxa which occur in most well-wooded, oceanic regions of the world. In rainforest, these species include Pseudocyphellaria crocata, Collema subflaccidum, C. fasciculare, Cladonia chlorophaea, C. ochrochlora, C. scabriuscula, Parmelia sinuosa, P. perlata, Lecanora atra, Usnea rubicunda, Megalaria grossa, Lecidella elaeochroma, Thelotrema lepadinum, Dimerella lutea, Psilolechia lucida, Chrysothrix candelaris and Lepraria incana, many of which reproduce asexually. Some are ubiquitous, wide-ranging species in Tasmania which only become common in rainforest in disturbed habitats. For example, where rainforest has been cleared for agriculture, isolated remaining trees often lose their typically "austral" epiphytes in favour of cosmopolitan "weedy" species.

The term "cosmopolitan" is rather loosely applied in this discussion. Although many of the species mentioned are world-wide, others are confined mainly to northern and southern temperate regions. Examples of such species in rainforest are Psoroma paleaceum, Cetraria chlorophylla, Arthonia cinereopruinosa, Bactrospora dryina, Cliostomum griffithii, Chaenotheca brunneola, Coniocybe furfuracea, Lecanactis abietina and Lopadium disciforme. These species could instead be called "bipolar", a term traditionally applied to chiefly Antarctic and Arctic taxa which in lower latitudes are confined to high mountains (Du Rietz 1940). Two major hypotheses have been advanced to explain bipolar distribution (see Du Rietz op. cit., Lindsay 1977, Sheard 1977, Schuster 1969, Singer 1954, Jørgensen 1983); firstly, that bipolar species are extreme instances of long range dispersal via mountain chains, or secondly, that bipolar taxa are old, pre-date the breakup of the continents and have managed to survive where they were insulated from climatic fluctuations (usually on high mountains). It is interesting that in Tasmania, the "bipolar-cosmopolitan" species listed above are all completely confined to closed, mature rainforest communities. Furthermore, within rainforest, most occupy very confined, specialised niches, usually on very old trees. It is difficult to conceive how such restricted species may be the products of long range dispersal, especially given that their habitat on a world scale is so fragmented. Hence it seems more likely that these lichens are the survivors of some primeval forest flora.

**Endemism**

Lichens tend to form few endemics, both because of their efficient dispersal and their slow evolution (cf. Jørgensen 1979, 1983). However, estimates of endemism are inevitably tied to the degree to which a region has been investigated. For example, an initial estimate of 1-2% endemism in the lichen flora of New Zealand by Galloway (1979) has subsequently increased to c. 50% (Galloway 1984) following the detailed studies of that author.

Ten endemic species (c. 5%) are currently known in the Tasmanian rainforest lichen flora : Bacidia weymouthii, Lecanactis "subpremnea", Menegazzia inactiva, M. minuta, M. retipora, M. subbullata, Micarea "mutabilis", Pseudopyrenula galactina, Ramalodium sp. and Sphaerophorus "ligulatus". However, another 35 species (17%)

from this survey have yet to be identified to species level and further taxonomic investigations could yield some additional endemic taxa. These are likely to occur in Psoroma, Siphula and Usnea, as well as in the crustose genera. Nevertheless, any increase in endemism is unlikely to be large. For example, during the present survey, several New Zealand "endemics" were discovered in Tasmania [see Appendix 1, Kantvilas et al. (1985), Kantvilas and James (in prep.)]. Conversely, Conotremopsis weberiana and Wawea fruticulosa, initially considered endemic to Tasmania, have since been collected in New Zealand and the common Tasmanian rainforest species, Megalospora lopadioides, is known also from a single collection from south-western Western Australia (Sipman 1983). Thus assessments of endemism will be unreliable as long as the different regions of Australasia and the Southern Hemisphere remain so unequally investigated.

## B. A KEY TO MACROLICHENS

This key is the first to be directed specifically towards rainforest, although recent years have seen an increasing availability of lichen keys for other regions or vegetation types in Australasia, e.g. Filson and Rogers (1979), Galloway (1985), Stevens and Rogers (1979). Although the key is designed for use in Tasmania, preliminary observations in cool temperate rainforest in Victoria suggest that it is also applicable there. The lichen flora of Victorian rainforest is comparatively reduced and includes a significant sclerophyll forest element but it also contains c.60% of the Tasmanian rainforest macrolichens. The key also has some relevance for rainforest species in New Zealand (D.J. Galloway pers. comm.) with 80% of the Tasmanian macrolichens common to both regions. However, New Zealand forests also contain numerous additional species (see Galloway 1985). It is recommended that the key be used in conjunction with Appendix 1 which contains habitat and distribution data as well as additional descriptive notes which may aid in the identification of the species.

## KEY TO SPECIES

1 Thallus foliose; lower surface with rounded, white or yellow spots or small craters.....2

Growth habit various, if foliose then lower surface lacking rounded spots or craters.....19

2 (1) Spots recessed, white, forming distinct craters with well-defined rims (cyphellae).....(Sticta)...3

Spots plug-like, not recessed, white or yellow and usually lacking a rim (pseudocyphellae) .....(Pseudocyphellaria)....6

3 (2) Upper surface grey-green when dry, bright green when wet, occasionally ± suffused red-brown; photobiont green; thallus without soredia or isidia, often fertile, ± stalked, sometimes attached to coralloid blue-green thalli of Dendriscocaulon dendriothamnodes .....Sticta stipitata

Upper surface brown to dark brown (tinged blue-green when wet or in extreme shade); photobiont blue-green; thallus sorediate or isidiate, neither stalked nor associated with Dendriscocaulon; fruits unknown in Tasmanian material; ± confined to forest margins.....4

4 (3) Thallus ± monophyllous, isidiate; isidia minute, laminal, terete, simple or coralloid, often in clusters .....Sticta fuliginosa

Thallus monophyllous or polyphyllous, sorediate.....5

5 (4) Lower surface with deep chocolate brown tomentum; thallus lobate, polyphyllous, spreading over the substrate; soralia chiefly marginal, labriform-linear .....Sticta sublimbata

Lower surface with fawn-brown tomentum; thallus shallowly lobed, ± monophyllous, not spreading, attached to substrate at one end only; soralia marginal and laminal, ± ulcerose.....Sticta limbata

6 (2) Medulla yellow.....7

Medulla white (pseudocyphellae and soralia may be yellow or white).....10

7 (6) Thallus sorediate; soralia yellow.....8

Thallus not sorediate.....9

8 (7) Upper surface thickly tomentose (use lens), grey to red-brown when dry, green when wet; photobiont green; soralia marginal and laminal.....*Pseudocyphellaria rubella*

Upper surface not tomentose, grey when dry, bright slatey blue-grey when wet; photobiont blue-green; soralia marginal.....*Pseudocyphellaria ardesiaca*

9 (7) Lobes ± elongate, with incised-serrated margins; isidia present, mainly marginal but also sometimes laminal; apothecium to 3-4 mm diam., with serrated, ± isidiate margin and reddish brown disc; medulla acetone + orange-yellow or yellow .....*Pseudocyphellaria colensoi*

Lobes ± rounded, with entire margins; isidia absent; apothecium 1-1.5 mm diam., with ± crenulate margin and ± black disc; medulla acetone + magenta .....*Pseudocyphellaria coronata*

10 (6) Thallus dark blue-green when wet, blue-grey, brown-grey or dark red-brown when dry; photobiont blue-green....11

Thallus green, green-grey or pale yellow-green when wet or dry; photobiont green.....15

11 (10) Thallus sorediate.....12

Thallus not sorediate.....13

12 (11) Pseudocyphellae yellow; soralia yellow, marginal and/or laminal; thallus usually brown when dry .....*Pseudocyphellaria crocata*

Pseudocyphellae white; soralia white, pale violet or bluish-grey, marginal or when laminal, pustular or punctiform; thallus usually blue-grey when dry .....*Pseudocyphellaria intricata*

13 (11) Minute, punctiform pseudocyphellae present on the upper surface (use lens); thallus isidiate; isidia coralloid-branched, marginal and laminal; apothecia unknown in Tasmanian material.....*Pseudocyphellaria argyracea* aggr.

Pseudocyphellae confined to the lower surface; isidia absent or, when present, not coralloid.....14

14 (13) Marginal phyllidia or ± flattened, dissected isidia present; thallus fragile, thin and papery, ± broadly lobed, with raised margins; usually on rocks, logs or tree buttresses; common.....*Pseudocyphellaria dissimilis*

Phyllidia or isidia absent; lobes elongated, narrow and richly divided, frequently bearing green leaflets of *Pseudocyphellaria subvariabilis*; usually in deep shade on logs or epiphytic; rare .....*Pseudocyphellaria* cf. *insculpta*

15 (10) Upper surface pale yellow-green, ± unchanged when wet; lower surface dark brown; lobes ± rounded at the tips, with marginal, easily abraded isidia or (rarely) granular soredia; very common polymorphic species .....*Pseudocyphellaria delisea*

Upper surface grey-green when dry, dark green when wet (rarely suffused brownish or blackish); lower surface cream to dark brown; lobes elongate, linear, with ± truncate tips.....16

16 (15) Thallus coarsely granular sorediate; soralia marginal and laminal, ± concolorous with the upper surface of the thallus; very rare and local in northern Tasmania .....*Pseudocyphellaria granulata*

Thallus not sorediate; common and widespread species.....17

17 (16) Upper surface of thallus smooth to undulate; lobes much divided, with folioles or small, lateral lobes along the margin; branching ± random; undersurface cream to light brown; apothecial disc red-brown .....*Pseudocyphellaria subvariabilis*

Upper surface markedly faveolate; marginal folioles absent; branching ± dichotomous; apothecial disc dark brown or black.....18

18 (17) Individual faveolae usually as broad as the lobes; marginal pseudocyphellae absent; apothecia mainly marginal; undersurface dark brown or sometimes fawn, particularly at the tips of the lobes; tomentum frequently patchy.....*Pseudocyphellaria billardieri*

Usually several faveolae spanning the width of the lobes; marginal pseudocyphellae present; apothecia marginal and laminal (on the ridges of the faveolae); tomentum on the undersurface very dense, dark brown, protruding somewhat beyond the lobe margins and visible from above as a slight fringe....*Pseudocyphellaria faveolata*

19 (1) Thallus filamentous, fluffy, composed of densely interwoven, hair-like threads giving the appearance of cotton wool.....20

Thallus not filamentous; growth form foliose, fruticose or squamulose.....24

20 (19) Thallus dark blue-green; filaments ± randomly dispersed over mosses or bark; fruit amorphous or ± 'bracket'-like, white, with minute pores, often underneath and obscured by the vegetative part of the thallus; basidiolichen, rarely found fertile.....*Dictyonema sericeum*

Thallus pale grey to orange-yellow, forming a ± continuous mat; fruit an apothecium.....21

21 (20) Thallus white to pale grey.....22

Thallus orange-yellow or orange-green (when fresh).....23

22 (21) Thallus a spreading, adnate mat, up to 40 cm wide or more; apothecia c. 0.5-1.2mm diam., plane, black, usually densely white pruinose and ± elevated in the centre of the thallus; photobiont filamentous; on the driest faces of the trunks of old trees; common .....*Sagenidium molle*

Thallus of small tufts of discrete, ± terete lobes c. 0.5 mm wide, with pale or pink, globose apothecia (0.3-0.4 mm diam.) at the tips; photobiont unicellular; on moist sides of tree trunks; rare .....*Roccellinastrum neglectum*

23 (21) Thallus bright orange-yellow to green, colour ± persisting in the herbarium; apothecia to 1 mm diam., rounded, plane, bright orange; on lowland, smooth-barked trees.....*Coenogonium implexum*

Thallus dull orange to green, mottled, fading to pale grey in the herbarium; fruits tubular, c. 0.3 mm diam. x 0.5 mm tall, flaring at the top, black and ± white-pruinose, particularly around the edge; on moderately dry trunks in high altitude forest...*Conotremopsis weberiana*

24 (19) Thallus fruticose*.....25

Thallus foliose or squamulose.....59

25 (24) Thallus comprising two growth forms: a crustose or squamulose primary basal thallus, and a secondary fruticose thallus of podetia or pseudopodetia, sometimes bearing fruits.....26

Thallus uniform.....34

26 (25) Primary thallus squamulose.....27

Primary thallus crustose or powdery (entirely sorediate)..31

27 (26) Primary thallus deeply lobed, coralloid-terete or ± flattened, 1-2 mm long; podetia shorter, indistinct, developing from the tips of the squamules; apothecia black, ± globose, capitate; confined to Eucalyptus bark and wood.....Gymnoderma melacarpum

Primary thallus usually shallowly lobed, always flattened; podetia distinctly taller (>5 mm), pointed (subulate) or cup-shaped (scyphose); apothecia brown or red (often absent); on various substrates .....(Cladonia)....28

28 (27) Podetia yellowish (usnic acid), K+ yellow (thamnolic acid), corticate, smooth or becoming rough and scaly; apices usually ± scyphose; apothecia red .....Cladonia subdigitata

Podetia pale green (lacking usnic acid), either corticate or ecorticate, subulate or scyphose; apothecia brown.....29

29 (28) Podetia with well-developed scyphi, coarsely granular sorediate in the upper part, especially within the scyphi.....Cladonia chlorophaea aggr.

Podetia subulate or with minute scyphi < 1 mm wide; soredia, if present, farinose.....30

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* "Fruticose" is used for all shrubby, erect or pendulous lichens and includes both dorsiventrally flattened and radially symmetrical thalli.

30 (29) Podetia K+ yellow, Pd+ orange (thamnolic acid), almost entirely ecorticate but covered with ± finely dissected squamules or coarse granules, tapering to a point (rarely to a narrow scyphus < 0.5 mm diam.).....*Cladonia squamosula*

Podetia K-, Pd+ red (fumarprotocetraric acid), corticate and squamulose, particularly towards the base, with farinose sorediate patches, frequently tapering to a narrow scyphus < 1 mm diam.....*Cladonia ochrochlora*

31 (26) Apothecium pink, flesh-coloured or pale brown; spreading over soil and rocks.....(*Baeomyces*)...32

Apothecium brown to black; epiphytic or on wood.....33

32 (31) Apothecia solitary on each podetium, bright rose-pink, convex and ± club-shaped, without a margin; thallus K+ yellow, Pd+ yellow → orange, UV+ white (baeomycesic and squamatic acids), ecorticate, often sorediate .....*Baeomyces fungoides*

Apothecia numerous and contorted or single on each podetium, whitish, flesh-coloured or pale to red-brown, ± flattened and disc-like, with a distinct margin paler than the disc; thallus K+ yellow → red, Pd+ orange, UV- (norstictic acid), corticate, not sorediate .....*Baeomyces heteromorphus*

33 (31) Thallus bright green to bronze-green; primary thallus granular-crustose; podetia granular-corticate, > 1 cm tall, furrowed and often longitudinally split; apothecia to 5 mm diam., convex.....*Pilophorus conglomeratus*

Thallus pale yellow-green to suffused brownish; primary thallus powdery, consisting of short, squamule-like, sterile podetia which are entirely or marginally sorediate; fertile pseudopodetia smooth corticate, <7 mm tall, hollow, with ± rounded perforations; apothecia < 1 mm diam., plane, numerous, crowded in blackberry-like clusters.....*Cladia schizopora*

34 (25) Thallus hollow.....35

Thallus solid or with a central axis.....37

35 (34) Pseudopodetia with perforations, corticate, smooth and shiny; squamules absent; very common, polymorphic species.....*Cladia aggregata*

Podetia lacking perforations, although axils may be open; either corticate and with squamules or ecorticate and lacking squamules.....36

36 (35) Podetia Pd+ red (fumarprotocetraric acid), sparingly branched, with open axils, corticate at the base, becoming aereolate and ecorticate towards the tips; peeling squamules present along the length of the podetia.....*Cladonia scabriuscula*

Podetia Pd- (perlatolic acid), intricately branched, forming compact, rounded cushions; axils closed; surface ecorticate, arachnoid (use lens); squamules always absent.....*Cladina confusa*

37 (34) Thallus dark coloured, blue-grey, olive-green or blackish; photobiont blue-green.....38

Thallus usually paler, greenish or grey; photobiont green.....41

38 (37) Thallus virtually not apparent when dry, becoming gelatinous and swelling noticeably when wet; lobes minute, < 1 mm tall, knob-like and irregularly shaped, dispersed over the substrate; spores simple, ± globose; very rare .....*Ramalodium* sp.

Thallus conspicuous even when dry, not or only slightly swelling when wet; lobes > 1 mm tall, ± regular and tapering, not knob-like, forming swards or tufts; spores septate, not globose (thallus often sterile).....39

39 (38) Thallus lobes to 5 mm long X 0.3 mm wide, erect or ascending, sparingly ± dichotomously branched, forming spreading swards; apothecia common, subglobose, multidivided, nestling among the lobes.....*Wawea fruticulosa*

Thallus lobes usually > 5 mm tall, intricately branched and tangled, forming tufts or dendroid clumps; apothecia unknown in Tasmanian material.....40

40 (39) Major branches dull, pale brownish, robust, to 1 mm wide, sparingly branched at the base, becoming blue-grey, richly coralloid towards the tips; forming stalked, dendroid clumps, frequently bearing green leaflets of Sticta stipitata .....Dendriscocaulon dendriothamnodes

Thallus ± entirely blue-grey, olive-green or ± blackish, glossy, very thin, delicate, densely branched and tangled, often decumbent at the tips; forming tufts; never stalked; green leaflets never present..Polychidium sp.

41 (37) Thallus terete.....42

Thallus flattened (at least in part).....49

42 (41) Thallus ecorticate, with numerous pale-grey, finger-like to coralloid phyllocladia and scattered, wrinkled, bluish cephalodia; apothecia terminal, convex, red-brown; firmly attached to rocks or pebbles .....Stereocaulon ramulosum

Thallus corticate, grey to yellow-green, without phyllocladia or cephalodia; apothecia not red-brown; usually epiphytic.....43

43 (42) Thallus with an elastic, white, central axis (seen by pulling the strands); fruit a flat or concave apothecium, concolorous with the thallus; usually a canopy or twig species.....(Usnea)...44

Central axis absent; fruit a black, dry, ± powdery mazaedium; usually a trunk species.....(Sphaerophorus)...48

44 (43) Thallus ± mottled greyish red-brown, with abundant pale yellow isidia and pseudoisidia developing from elongated papillae.....Usnea rubicunda

Thallus uniformly grey to yellow (sometimes discoloured brownish at the base); either fertile or with asexual propagules.....45

45 (44) Thallus pendulous, straggling, very limp and lax, > 10 cm long, very pale yellow-grey to green-grey, rather fragile; main branches loosely entangled, thin (c. 0.5 mm); short secondary lateral branches sparse .....Usnea capillacea

Thallus < 10 cm long, erect-shrubby or subpendulous, ± pale yellow to green-grey; main branches to 1.5 mm thick; laterals usually abundant.....46

46 (45) Branches without asexual propagules or pseudocyphellae; apothecia terminal, usually numerous.....*Usnea molliuscula*

Branches with pseudoisidia and pseudocyphellae, particularly towards the apices; apothecia subterminal, usually absent.....47

47 (46) Salazinic acid present (medulla Pd+ orange, K+ yellow → red); secondary branches often constricted at point of attachment to main stem; short, spike-like laterals ± numerous; common and widespread.....*Usnea arida*

Fumarprotocetraric acid present (medulla Pd+ red, K ± pale sordid brown); secondary branches tapered, ± without constrictions or short, spike-like laterals; local in some high altitude forests.....*Usnea* sp.

48 (43) Thallus yellowish (isousnic acid), with wider main branches bearing laterals with richly branched, coralloid outgrowths; mazaedia subterminal on the ventral surface of the main branches .....*Sphaerophorus ramulifer*

Thallus pale grey or whitish; branches entangled, ± uniform in thickness, without outgrowths; mazaedia terminal, carried conspicuously above the mass of the thallus on stouter branches.....*Sphaerophorus tener*

49 (41) Thallus white to very pale grey, uniformly coloured, K+ yellow (thamnolic acid); fruits unknown....(*Siphula*)...50

Thallus olive-brown, greenish yellow or pale greenish blue, with a darker coloured upper surface and a usually off-white lower surface, K-; apothecia present or absent.....51

50 (49) Thallus very pale grey, sometimes with a faint bluish tinge, forming ± compacted tufts; lobes to 5 mm wide, branched and convoluted, with numerous fenestrations, scabrid, mealy, particularly on the underside .....*Siphula* cf. *dissoluta*

Thallus chalky white, subpendulous when well-developed; lobes 0.5-1.2 mm wide, sparingly branched, markedly strap-shaped to subterete, elongated, without fenestrations, smooth or scabrid.....*Siphula* sp.

51 (49) Lobes 1-2 mm long; apothecia black, globose, terminal on short (< 2 mm) podetia; confined to *Eucalyptus* wood or bark.....*Gymnoderma melacarpum*

Lobes usually longer than 5 mm; apothecium a black, dry, powdery mazaedium, subterminal on the underside of the main lobes; on various substrates, rarely on *Eucalyptus*.....(*Sphaerophorus*)...52

52 (51) Branches supporting the apothecia markedly flattened, more than twice as broad as thick.....53

Branches supporting the apothecia ± subterete, less than twice as broad as thick; (broadly flattened sterile branches may be present also).....57

53 (52) Medulla Pd+ red (protocetraric acid); spores brownish.....54

Medulla Pd-; spores brownish or grey-brown.....56

54 (53) Spores 6-8 um diam; fertile branches not or only sparingly branched, tongue-like, with rounded apices, often ± deflexed and forming a hood around the mazaedium; margins entire, without short lateral branchlets .....*Sphaerophorus ligulatus*

Spores 10-16 um diam; fertile branches moderately to much branched, frequently with short lateral branchlets along the margins.....55

55 (54) Mazaedium covered by a thin white veil which only ruptures at maturity; very common.....*Sphaerophorus insignis*

Mazaedium soon exposed (although sometimes partially covered by the incurved walls of the receptacle); uncommon.....*Sphaerophorus murrayi*

56 (53) Fertile branches c. 5-14 mm wide, waisted below a ± conical apothecium with flared thalline margins and coarsely scrobiculate upper surface; sphaerophorin absent; spores grey-brown, (8-)10-14 um diam.; upper surface of thallus usually greyish green .....Sphaerophorus scrobiculatus

Fertile branches c. 3 mm wide, not waisted below the apothecium; apothecium ± flattened, with margins not apparent and with smooth to ± convoluted upper surface; sphaerophorin present; spores brownish, 12-15 um diam.; upper surface of thallus ± olivaceous yellow-green.....Sphaerophorus patagonicus

57 (52) Apothecium distincly enlarged, almost hemispherical, notably wider than the supporting branch; spores brownish-grey, 8-12 um diam.....Sphaerophorus macrocarpus

Apothecium ± as broad as the supporting branch; spores colourless to purple-grey, 5-10 um diam.....58

58 (57) Thallus yellowish (iso-usnic acid), with richly branched, ± terete, coralloid, lateral outgrowths; spores 8-10 um diam;.....Sphaerophorus ramulifer

Thallus pale bluish green; laterals dorsiventrally flattened; spores 5-8 um diam.....Sphaerophorus melanocarpus

59 (24) Thallus homoiomerous, entirely dark bluish-black or olive-green, often swelling noticeably when wet and becoming ± gelatinous; photobiont blue-green.....60

Thallus heteromerous, variously coloured, never swollen or gelatinous when wet; photobiont blue-green or green....71

60 (59) Thallus extremely turgid and pulpy when wet.....61

Thallus sometimes ± swollen when wet but nevertheless remaining flat.....64

61 (60) Thallus spreading, ± lobate, ridged, fenestrate, white-grey tomentose on the upper surface; margins of apothecia ± white pruinose; spores simple.....Physma chilense

Thallus pulvinate and forming button-like lumps when wet, not tomentose; apothecia without white pruinose margins; spores simple or septate.....62

62 (61) Thallus ± flat, with fenestrations and ridges covered with granular isidia when dry, swelling to a pulpy, granular cushion when wet; apothecia dispersed; spores simple; very rare canopy species.....*Physma* sp.

Thallus button-like and wrinkled even when dry, with or without isidia, swelling to an intensely folded, convolute, lobed cushion when wet; apothecia absent or clustered; spores septate; frequent at scrubby rainforest margins.....63

63 (62) Thallus with abundant wart-like isidia and a cellular cortex; apothecia unknown in Tasmanian material .....*Leptogium brebissonii*

Thallus without isidia, lacking a cellular cortex; apothecia abundant, ± obscuring the thallus .....*Collema fasciculare*

64 (60) Thallus with a cellular cortex one cell thick (use microscope).....(*Leptogium*)...65

Thallus lacking a cortex.....(*Collema*)...67

65 (64) Lower surface with well-developed white-grey bushy rhizines; marginal and laminal squamiform isidia present.....*Leptogium limbatum*

Lower surface naked; isidia present or absent.....66

66 (65) Thallus robust, markedly wrinkled on the upper surface, grey to deep red-brown, with overlapping concave lobes and squamiform isidia; spores 13-24 x 5-8.5 um, with 3 transverse and 1 longtitudinal septa .....*Leptogium victorianum*

Thallus thin and papery, flat and smooth, ± bluish grey, without isidia; spores 25-33 x 9-13 um, with 4-7 transverse and 1-3 longtitudinal septa .....*Leptogium azureum*

67 (64) Thallus ± covered with numerous, globular isidia; apothecia unknown in Tasmanian material .....*Collema subflaccidum*

Thallus not isidiate, commonly fertile.....68

68 (67) Thallus surface prominently ridged, pustular and ± fenestrate, particularly when wet....*Collema glaucophthalmum*

Thallus often irregularly folded and undulate but surface smooth, not pustular.....69

69 (68) Spores muriform, broadly fusiform to ellipsoid; thallus bluish grey to olive-green.....*Collema subconveniens*

Spores transversely septate only, acicular; thallus dark olive-green.....70

70 (69) Apothecia to c. 0.75 mm diam., immersed when young, slowly becoming emergent; thalline margin non-corticate; disc either ± pruinose (= var. *laeve*) or epruinose (= var. *senecionis*).....*Collema laeve*

Apothecia to 1.5 mm diam., soon superficial; thalline margin with a thick pseudocortex; disc strongly white pruinose.....*Collema leucocarpum*

71 (59) Undersurface black and shiny, without rhizines.....72

Undersurface white to brown; if black, with rhizines or a tomentum.....89

72 (71) Upper surface without perforations; lobes solid or hollow.....73

Upper surface with few to numerous perforations; lobes always hollow.....(*Menegazzia*)...78

73 (72) Upper surface green, suffused brownish or olive; lobes minute (to 1 mm wide), short and crowded; isidia present (sometimes sparsely), hollow, ± decumbent .....(*Menegazzia*)...74

Upper surface grey, sometimes partially blackened; lobes larger, elongate; isidia never present.....(*Hypogymnia*)...75

74 (73) Upper surface olive or suffused red-brown; medulla Pd-, K- (protolichesterinic acid); isidia sparse, ± globular; thallus small, < 10 mm across; very rare subcanopy twig species.....*Menegazzia minuta*

Upper surface green-grey, rarely ± suffused brownish olive-green; medulla Pd+ orange, K+ yellow (stictic acid); isidia conspicuous, finger-like, rather crowded; thallus forming rosettes, usually > 20 mm across; uncommon trunk species.....*Menegazzia eperforata*

75 (73) Thallus with ± diffuse laminal soralia; main lobes mostly hollow.....*Hypogymnia subphysodes*

Thallus not sorediate; main lobes solid or hollow.....76

76 (75) Main lobes solid, ± flattened.....*Hypogymnia mundata*

Main lobes mostly hollow, terete or subterete.....77

77 (76) Medulla Pd+ orange (physodalic acid); lobes deeply divided, separate and elongated throughout .....*Hypogymnia lugubris*

Medulla Pd-; lobes ± contiguous in the centre of the thallus, becoming distinctly separated only towards the tips.....*Hypogymnia turgidula*

78 (72) Thallus sorediate, very rarely fertile.....79

Thallus without soredia, commonly fertile.....85

79 (78) Upper surface yellow (usnic acid); soralia in laminal helmet-shaped pustules; medulla C+ red (lecanoric acid).....*Menegazzia globulifera*

Upper surface pale grey to brownish green; soralia not helmet-shaped; medulla C-.....80

80 (79) Lobes to 1 mm wide; upper surface brownish green to grey; soralia derived from coarse, torn and abraded laminal pustules.....*Menegazzia nothofagi*

Lobes > 1.5 mm wide; upper surface grey (lobe ends may be suffused brownish); soralia superficial, not developed from pustules.....81

81 (80) Lobes 2.5-4 mm wide, elongated, turgid- inflated, ± terete, with a smooth to ± weakly wrinkled upper surface; soralia laminal or developing at or near the tips of short lateral and terminal lobes; common high altitude twig species.....*Menegazzia subbullata*

Lobes to 3 mm wide, subterete to flattened; surface ± smooth; soralia laminal or associated with the perforations; uncommon species of lowland or sheltered forests.....82

82 (81) Upper part of internal wall of medullary cavity orange-yellow, K+ purple (anthraquinone pigments) .....*Menegazzia caliginosa*

Internal wall of medullary cavity white, K+ yellow or K- (no pigments).....83

83 (82) Medulla and soralia Pd+ orange, K+ yellow (stictic acid); edges of perforations flush with the upper surface or turned inwards; common species of open sclerophyll forest, very rare in rainforest.....*Menegazzia subpertusa*

Medulla and soralia Pd-, K-; edges of perforations turned outwards.....84

84 (83) Medulla UV+ ice-white, KC+ pink (alectoronic acid); perforations not significantly elevated; soralia laminal or unevenly developed near the edges of the perforations.....*Menegazzia ultralucens*

Medulla UV-, KC- (fatty acids); soralia confined to the edges of markedly elevated, cone-like perforations .....*Menegazzia inactiva*

85 (78) Upper cortex reddish to dark chestnut brown (or brownish grey in extreme shade); spores 2/ascus; subalpine-alpine species, very rare in rainforest.....*Menegazzia testacea*

Upper cortex very pale grey or green-grey (lobe ends may be suffused brownish); spores 2 or 8/ ascus.....86

86 (85) Lobes 0.5-1 mm wide, markedly flattened at the tips; perforations often forming a reticulum; spores 2/ascus .....*Menegazzia retipora*

Lobes 1.5-5 mm wide, not markedly flattened at the tips; perforations abundant but not forming a reticulum.....87

87 (86) Lobes 4-5 mm wide, swollen, with wrinkled-corrugated upper surface; apothecia with markedly inflated-corrugated margins; alpine or subalpine species .....*Menegazzia bullata*

Lobes 1.5-3 mm wide, not swollen or corrugated; apothecia with a thin margin.....88

88 (87) Spores 8/ascus; medulla Pd-, K- (protolichesterinic acid); surface ± shiny and smooth (use lens); very common canopy or upper trunk species .....*Menegazzia weindorferi*

Spores 2/ascus; medulla Pd+ orange, K+ yellow (stictic acid); surface ± matt, often very faintly rugose (use lens); usually a twig species in rainforest, also common in sclerophyll forest.....*Menegazzia platytrema*

89 (71) On rocks or bare soil; thallus placodioid, ± subcrustose and lobed only at the margins, glaucous grey to creamish fawn, sorediate and/or with rose-pink lecanorine apothecia; cephalodia present....*Placopsis gelida*

Substrate various, rarely rocks or soil; thallus foliose or squamulose; colour various; soredia present or absent; rose-pink lecanorine apothecia never present; cephalodia present or absent.....90

90 (89) Thallus small-squamulose, consisting of numerous, contiguous or scattered small scales, usually closely adnate to the substrate, commonly dispersed over a black prothallus.....91

Thallus foliose, with well-defined, radiating lobes, loosely attached or adnate; prothallus sometimes evident .....104

91 (90) Thallus entirely blue-grey or dark brown-grey; photobiont blue-green.....92

Thallus pale greyish, green to yellow-green; photobiont green; blue-grey or flesh-coloured cephalodia often present.....95

92 (91) Apothecia lecideine (or absent), rarely with a few enveloping marginal thalline squamules; thallus dark blue-grey; very common and polymorphic .....*Parmeliella nigrocincta* aggr.

Apothecia lecanorine, with a conspicuous, persistent thalline margin; thallus pale lead-grey or dark brown-grey; uncommon.....(*Pannaria*)...93

93 (92) Squamules dark grey to brown-grey, thick, sometimes ± ascending; apothecia numerous, usually crowded to ± contiguous; disc red-brown to dark brown; thalline margin thick, totally obscuring the proper margin; frequent at forest margins, mainly on *Eucalyptus*, *Leptospermum* or *Cassinia*.....*Pannaria* aff. *pezizoides*

Squamules pale lead-grey, thin, adnate throughout; apothecia scattered; disc pale orange-brown, occasionally blackened; thalline margin thin, sometimes with small gaps; proper margin thin, ± concolorous with disc; rare on smooth bark in the forest understorey.....94

94 (93) Apothecial disc with faint gyrose markings and a central depression.....*Pannaria immixta*

Apothecial disc smooth, without gyrose markings or a central depression.....*Pannaria* sp.

95 (91) Squamules yellow-green (usnic acid), with marginal granular soredia.....*Psoroma soccatum*

Squamules yellow-green, green or greenish grey, not sorediate.....96

96 (95) Apothecia lecideine.....97

Apothecia lecanorine.....(*Psoroma*)...99

97 (96) Cephalodia absent; apothecial disc scabrid-verrucose (use lens), orange to deep rusty red-brown; thallus C+ red (gyrophoric acid); occurring mainly at high altitudes on rotting wood, humus or old bark .....*Phyllopsora congregans*

Cephalodia present; apothecial disc smooth, pale orange-brown to black-brown; thallus C-; on smooth bark, rarely also on rocks.....(*Psoromidium*)...98

98 (97) Apothecia ± clustered, red-brown to black-brown; squamules pale blue-grey when dry, bright green when wet; prothallus well-developed, ± byssoid; forming large patches up to 10 cm wide on tree trunks, rarely on rocks.....*Psoromidium aleuroides*

Apothecia scattered, red-brown; squamules pale to ± translucent green when dry, pale green when wet; prothallus absent or thin; tiny, ± subcrustose twig species.....*Psoromidium versicolor*

99 (96) Margins of apothecia with dense tomentum of long hairs; squamules inconspicuous, ± granular; muscicolous on tree trunks in high altitude forest.....*Psoroma paleaceum*

Apothecial margins naked; squamules conspicuous, not granular; mainly corticolous.....100

100 (99) Squamules very closely appressed, ± contiguous and usually forming a crust.....101

Squamules at least partially ascending, ± discrete and dispersed, not forming a crust.....102

101(100) Squamules pale green to yellow-green (usnic acid) when wet or dry, crenate-lobulate, forming a thick, uneven, aereolate crust; prothallus well-developed, black, often ± byssoid; thalline margin of apothecium thick, ± inrolled (even in mature fruits); spores with thick, smooth epispore with prominent, broadly acuminate to rounded apiculae; common.....Psoroma pholidotoides

Squamules dull green when wet, olivaceous green-grey when dry, deeply incised, microphylline, very thin; prothallus very thin, patchy, film-like, grey-black; thalline margin thin, not or scarcely inrolled; spores with thin, distinctly warted epispore, lacking prominent apiculae; rare.....Psoroma sp. 1

102(100) Squamules ascending, becoming almost perpendicular to the substrate, deeply dissected, elongate, c. 0.5 mm wide, forming a fruticose cushion c. 5 mm high; apothecia 2-3 mm diam.....Psoroma sp. 2

Squamules only partially ascending, ± roundish with shallowly incised, ± crenate margins; apothecia 1-1.5 mm diam.....103

103(102) Squamules glaucous-grey, Pd+ orange-red (pannarin); apothecial disc red-brown to dark brown, ± pruinose when young; cephalodia not apparent; spores with smooth epispore.....Psoroma sp. 3

Squamules bright green when wet, grey-green when dry, Pd-; apothecial disc orange-pink, epruinose; cephalodia conspicuous, usually abundant; spores with minutely roughened epispore.....Psoroma asperellum

104 (90) Underside with distinct pale or brown veins, bearing bushy rhizines; apothecia marginal, elevated on the tips of ascending, finger-like, often recurved lobes; blue-green species of the forest floor, on soil, logs

or buttresses of trees.....Peltigera dolichorhiza

Underside without veins; apothecia not elevated on finger-like lobes; mainly epiphytic.....105

105(104) Apothecia on the underside of lobe apices; undersurface naked and white.....(Nephroma)...106

Apothecia never on the underside; undersurface naked or with rhizines or tomentum, variously coloured.....107

106(105) Photobiont green; upper surface yellow-green to bronze-green, smooth (except for the scabrid upper surface of the fertile lobes); lower surface ± smooth .....*Nephroma australe*

Photobiont blue-green; upper surface dark brown (blue-green when wet or in extreme shade), deeply reticulate-faveolate; lower surface bullate.....*Nephroma cellulosum*

107(105) Thallus pale to dark blue-grey; photobiont blue-green.....108

Thallus ash-grey, yellow, green or brown; photobiont green.....112

108(107) Lobes c. 5-10 mm wide, rounded; margins recurved; upper surface ± faintly striate, not scabrid (use lens); lower surface with dense felt-like mat of bluish grey or cream rhizines extending to the margin .....(*Degelia*)...109

Lobes to c. 5 mm wide , incised; margins flat or ascending; surface ± scabrid or tomentose, not striate; rhizines sparse or in thick tufts but never forming a dense continuous felt to the margin.....(*Leioderma*)...110

109(108) Thallus isidiate, rarely fertile; apothecia with a ± incomplete isidiate thalline margin.....*Degelia durietzii*

Thallus without isidia, commonly fertile; apothecia without a thalline margin.....*Degelia gayana*

110(108) Thallus not sorediate; apothecia orange-brown to brown, usually abundant; twig species.....*Leioderma pycnophorum*

Thallus with marginal soredia; apothecia unknown in Tasmanian material; on tree trunks, usually overgrowing bryophytes.....111

111(110) Upper surface of thallus ± uniformly arachnoid-tomentose, dark blue-green when wet, pale grey when dry; lobes concave; margins ascending; very rare...*Leioderma sorediatum*

Upper surface of thallus ± scabrid, not tomentose, bluish-grey to somewhat brownish when wet or dry; lobes plane; margins adnate; common.....*Leioderma amphibolum*

112(107) Upper surface brown to olive.....113

Upper surface grey, green or yellow.....114

113(112) Lobes elongate, ± ascending, with crisped, ± obscurely sorediate margins; undersurface cream to fawn, shiny, without rhizines; medulla C- (protolichesterinic acid).....Cetraria chlorophylla

Lobes short, rounded and imbricate, ± entirely closely adnate; soralia terminal to submarginal (frequently very sparse); undersurface tan to black, with rhizines; medulla C+ red (gyrophoric acid).....Parmelia subglabra

114(112) Upper surface yellow or yellow-green (usnic acid); lobes ± linear-elongated, forked-branched.....115

Upper surface grey or green (without usnic acid); lobes usually rounded (if ± linear, then neither yellow nor forked-branched).....116

115(114) Thallus sorediate; soralia on ascending, ± reflexed lobe tips; axils of branches sinuate; undersurface ± uniformly covered with numerous branched, black rhizines; medulla K+ yellow -> red (salazinic acid)...Parmelia sinuosa

Thallus not sorediate; lobe tips not reflexed, ± rounded; axils of branches ± angular; under-surface with dense, dark brown, contiguous, cushion-like, tomentose areas; medulla K-(divaricatic acid) .....Pannoparmelia angustata

116(114) Undersurface ecorticate, white, with black rhizines and sparse black, hair-like cilia (particularly towards the lobe tips); thallus whitish grey, with marginal squamules which become coarsely sorediate; rare in rainforest.....Heterodermia microphylla

Undersurface corticate, black or brown, or if white, then without rhizines or cilia (although frequently with a black prothallus); thallus grey or green, sorediate or esorediate.....117

117(116) Undersurface black to dark brown, becoming ± paler at the margins; black rhizines present; upper surface whitish grey; cephalodia never present.....(Parmelia)...118

Undersurface pale cream, without rhizines but with a pale tomentum or black prothallus; upper surface pale green or greyish to bluish green; cephalodia present .....(Psoroma)...126

118(117) Upper surface marked with white, ± sigmoid or elongate maculae which often become cracks (pseudocyphellae) (use lens); medulla C-.....119

Upper surface without maculae or pseudocyphellae; medulla C+ red or C-.....122

119(118) Margins of lobes sorediate.....120

Soredia absent.....121

120(119) Lobes c. 1-3 mm wide, elongate, rather thin and delicate; medulla Pd+ red, K+ yellowish (protocetraric acid); uncommon.....Parmelia protosulcata

Lobes > 4 mm wide, rounded, coarse and thick; medulla Pd+ orange, K+ yellow → red (salazinic acid); common .....Parmelia cunninghamii

121(119) Lobes to 7 mm wide, ± concave, with rounded ends and irregularly incised, ascending margins....Parmelia tenuirima

Lobes 1-2 mm wide, usually ± flat, neatly ± linear-elongated, with truncate tips.....Parmelia testacea

122(118) Lobes markedly concave, ± broadly rounded; margins ascending, with discrete oval-shaped soralia; medulla C-, K+ yellow (stictic acid); species of sclerophyll forest, very rare in rainforest.....Parmelia perlata

Lobes flat to convex, often with ± truncate apices; margins adnate, undulate or revolute; soralia absent or developing from laminal or submarginal pustules; medulla C+ red or C-, K-; canopy species, usually poorly developed.....123

123(122) Thallus without soredia or laminal pustules; medulla C+ red (lecanoric acid).....Parmelia pruinata

Thallus sorediate, or with irregular laminal pustules which may become sorediate; medulla C+ red (gyrophoric acid) or C-.....124

124(123) Medulla C- or very fleeting pale pink; thallus with pustules (often in exuberant masses)which may become abraded but not sorediate.....Parmelia subfatiscens

Medulla C+ red; (gyrophoric acid); thallus sorediate; soralia usually developing from laminal or subapical pustules.....125

125(124) Margins of lobes ciliate (sometimes only sparsely); axils ± rounded; common and widespread.....*Parmelia* cf. *revoluta*

Margins of lobes eciliate; axils ± irregularly incised; rare.....*Parmelia labrosa*

126(117) Thallus attached ± centrally, with loose, free, ascending lobes; underside whitish, tomentose; uncommon, usually on twigs of undershrubs.....*Psoroma euphyllum*

Thallus tightly adnate throughout, frequently on a black, ± fibrous prothallus; lobes radiating, often larger and more evident at the periphery.....127

127(126) Cephalodia dissolving into conspicuous blue-grey soredia.....*Psoroma durietzii*

Cephalodia not sorediate, frequently ± obscure.....128

128(127) Thallus pale glaucous green when wet, ± unchanged or yellow-brown when dry, Pd+ orange-red (pannarin); lobes 2-5 mm wide, with granular sorediate margins; uncommon, found mostly in high altitude forests.....*Psoroma leprolomum*

Thallus colour various, bright green, pale glaucous green or brownish, Pd-; lobes 1-2 mm wide; margins not sorediate, with dense, globular or flattened phyllidia or nodules, often eroded.....129

129(128) Thallus bright green when wet, grey-green when dry, turning ± olivaceous to cinnamon brownish green in the herbarium; upper surface smooth; margins commonly eroded; very common throughout rainforest, mostly on smooth bark.....*Psoroma microphyllizans*

Thallus pale glaucous green, often with a ± yellowish tinge when wet or dry; upper surface minutely scabrid, ± mealy; margins phyllidiate, never eroded; restricted to rainforest margins or to wet sclerophyll forest .....*Psoroma* sp. 4

# III ECOLOGY

## A. DISTRIBUTION AND ECOLOGY OF TASMANIAN RAINFOREST LICHENS*

This section deals with general aspects of the rainforest lichen flora in Tasmania. It is descriptive in approach and provides a general framework for the more detailed studies outlined in parts IIIB and IIIC (below).

### Methods

As with the preceding sections, the information presented here is derived from several sources including a general survey of rainforest in Tasmania, several detailed studies in selected areas and from cursory sampling in a wide range of vegetation types.

The broad study of rainforest lichens was undertaken during a general botanical survey of Tasmanian rainforest (see Jarman et al. 1984) which examined over 300 rainforest sites. Lichen data were obtained mainly from the lower levels of the forest (up to 3-4 m above the ground). Presence/absence data and subjective assessments of abundance and habitat were recorded. Limited data on canopy lichens were derived from the examination of litter, fallen branches and, where available, recently fallen trees.

Several more systematic investigations were undertaken to examine particular aspects of lichen ecology. These are reported in detail in subsequent sections but many of the general results and their implications are incorporated here. They include a study of the vertical zonation of lichens at Sumac Road, north-western Tasmania, and a study of lichen communities in the valley of the Little Fisher River. Observations from pilot studies conducted at Five Road (Florentine Valley) and at Ben Ridge (north-eastern Tasmania) are also discussed although the studies themselves are not documented. Both involved thorough sampling and collection of the lichens of entire trees during a period of familiarisation with the flora. The location of these sites (and other areas mentioned in the text) is shown in Figure 2.

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* This section is based in part on Kantvilas, G., James, P.W. and Jarman, S.J. (1985) Macrolichens in Tasmanian rainforest. Lichenologist 17: 67-83.

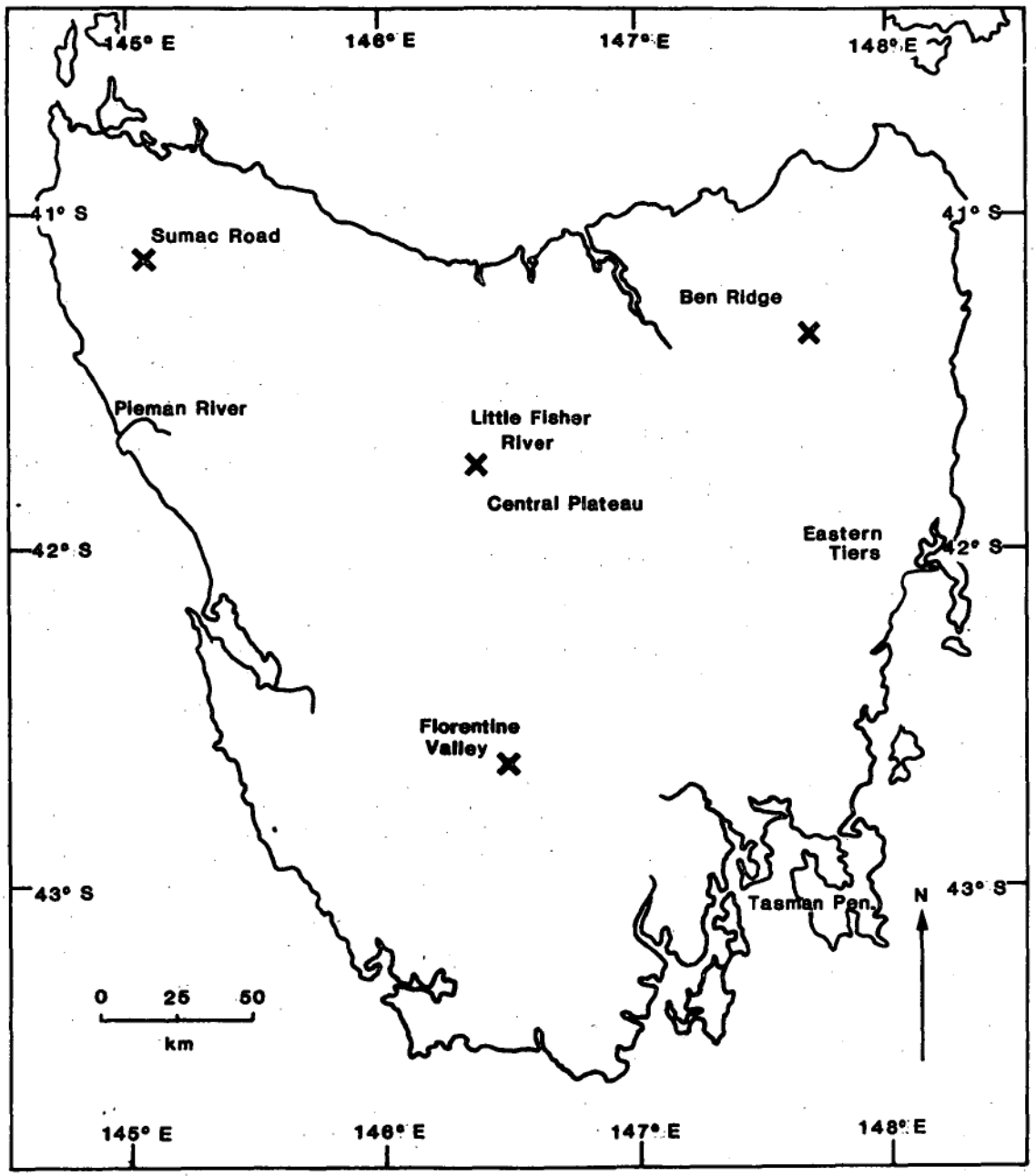



Figure 2. Location of places mentioned in the text.

**Distribution in Tasmania**

Approximately 60% of the lichens found in rainforest have been recorded in other vegetation types also. The remaining species appear to be confined to rainforest but most of these are rare and known from only very few collections, e.g. Lecanactis subpremnea, Megalospora subtuberculosa, Menegazzia inactiva, M. minuta, Pannaria immixta, Physma sp. and Roccellinastrum neglectum. Some crustose lichens, such as species of Lecidea and Catillaria, are too poorly known for any meaningful conclusions to be drawn regarding their distribution. Most of the more common lichens confined to rainforest have very restricted ecological amplitudes. For example, Sagenidium molle, Conotremopsis weberiana, Lecanactis abietina, Micarea spp., Bactrospora spp. and Arthonia cinereopruinosa are all confined to the dry faces of very old tree trunks. Similarly, Psoromidium versicolor and Psoroma euphyllum occur mostly on understorey twigs. In general, the microlichens tend to be more restricted ecologically than do the macrolichens, probably because they are in more intimate contact with their host and hence more finely attuned to their micro-environment.

Many of the other habitats which contain rainforest lichens, e.g. moorlands, wet heaths, scrub or sclerophyll forest, also contain phanerogams from rainforest communities. Furthermore, these vegetation types often abut or occur in mosaics with rainforest and some may be seral stages in the development of rainforest (see Jackson 1968, Jarman et al. 1982). In these situations, it is not surprising to find the incipient development of a rainforest lichen flora. Examples of rainforest lichens found in seral vegetation include: Pseudocyphellaria billardieri, Phlyctella subuncinata, Bacidia weymouthii and Megaloblastenia marginiflexa (wet sclerophyll forest); Austroblastenia pauciseptata, Coccotrema cucurbitula, Nephroma spp., Pseudocyphellaria rubella and Wawea fruticulosa (wet heath and scrub); and Sphaerophorus tener, Pseudocyphellaria delisea, P. subvariabilis and Psoroma microphyllizans (widespread). Other vegetation types which contain rainforest phanerogams and lichens can be interpreted as degraded communities derived from rainforest. These include wet gully communities in eucalypt forest in the eastern half of Tasmania and scrub around fire-protected rock outcrops in the South-West (see also p.70).

A correlation between high rainfall (1600 mm annually) and the distribution of particular rainforest lichens (Pannoparmelia

angustata, Pseudocyphellaria delisea and Sticta stipitata) has been demonstrated by Bratt et al. (1976) and Rundel et al. (1979), and it is likely that the same correlation applies to other species. Work aimed specifically at the distribution of the rainforest lichens, Wawea fruticulosa (Henssen & Kantvilas 1985) and "Asteristion" lamelliferum (in prep.), revealed distributions which roughly accord with the 1150 mm isohyet, i.e. the western half of Tasmania with outlying populations in the north-eastern highlands. This type of distribution is also featured by Nothofagus cunninghamii and several other rainforest phanerogams. Therefore, it is difficult to separate the influences of high rainfall and of the rainforest vegetation itself on the lichen flora, at least with respect to those lichens which are not confined to some specialised rainforest habitat. This is especially so because high rainfall predisposes the vegetation of an area towards rainforest.

Further evidence for the strong influence of rainfall on lichen distribution is found in the predominance of rainforest lichens on the wetter western and southern coasts in exposed dune and shoreline vegetation, habitats normally associated with Ramalina, Parmelia, the Physciaceae and the Teloschistaceae. Similarly, along the eastern edge of the Central Plateau, lichens of dry, lowland sclerophyll forest (Xanthoparmelia, Physcia, Ramalina) are replaced with increasing altitude and rainfall by species of Pseudocyphellaria, Psoroma and Nephroma, even though this area is far removed from rainforest. Mist and fog would also contribute significantly to the overall humidity of such areas.

Despite the wide distribution of so many of its constituent species, the rainforest lichen flora remains distinctive. Its essential character derives not necessarily from the presence of particular species but from their degree of development and, more importantly, the presence of unique lichen associations. For example, dry, mature trunk communities which contain Sagenidium molle, Coniocybe furfuracea, Chaenotheca brunneola, Lecanactis abietina and Lepraria incana are characteristic of rainforest, despite the widespread nature of at least some of their constituent species. The same applies to wet, mature trunk communities containing Sphaerophorus insignis, S. melanocarpus, Pilophorus conglomeratus, Thelotrema subdenticulatum and "Asteristion" lamelliferum. At the individual species level, species such as Austroblastenia

pauciseptata, Menegazzia weindorferi, Pseudocyphellaria subvariabilis, Sphaerophorus tener, Dimerella lutea and Megalospora lopadioides, though wide-ranging, rarely attain the degree of lushness or fertility outside rainforest as they do within it. Furthermore, outside rainforest they are usually subordinate members of quite different lichen associations. Conversely, however, several species recorded in rainforest are clearly non-rainforest species which are best developed in other habitats or in some of the pre-rainforest seral stages. Examples of these species include Collema leucocarpum, Parmelia pruinata, Degelia gayana, Coenogonium implexum, Lecanora atra, Lecidella elaeochroma, Leptogium azureum and Lecidea laeta.

In general, no strong regionalism is evident amongst the Tasmanian rainforest lichens. Most species, particularly those which are more common, are widespread throughout the range of rainforest in the state. However, three very broad distribution centres, correlated partly with the distribution of particular rainforest communities (see pp.66-70) can be discerned amongst the less common species, although almost invariably, outlying populations are also known.

One group is centred in western and south-western Tasmania and includes Sphaerophorus scrobiculatus, S. murrayi, S. macrocarpus, Roccellinastrum neglectum, Siphula spp., Pertusaria sp.2 and Pseudocyphellaria argyracea aggr. A second group is centred in the mainly high altitude rainforests of northern and north-eastern Tasmania and the Central Plateau. This group includes Conotremopsis weberiana (not found in the North-East), Sphaerophorus patagonicus, Catinaria sp., C. pulverea, Usnea sp., Ramonia muscicola, Hypogymnia subphysodes and Cetraria chlorophylla. A significant number of additional, rare species are at present known only from within this region (Little Fisher River) but this is most probably due to the intensity of the investigations which have been undertaken there. Such species include Micarea mutabilis, Pertusaria sp.1 and Fuscidea sp. Pseudocyphellaria granulata is also local in this region but is found mostly outside of rainforest on rock outcrops. A third centre of distribution of rainforest lichens is north-western Tasmania but again, this impression results partly from the intensive studies carried out at Sumac Road and other forests near the Arthur River. Species local in this region include Heterodermia microphylla (rainforest form), Psoroma euphyllum, Bactrospora spp., Schismatomma

sp., Menegazzia eperforata, M. inactiva, Lopadium disciforme, Megalospora subtuberculosa and Thelotrema decorticans. Several additional, rare species are known from single collections from this area, e.g. Physma sp., Ramalodium sp., Lecanactis subpremnea and Leioderma sorediatum.

**Factors affecting lichen distribution**

Potential factors influencing the development of epiphytic lichen communities are listed by James et al. (1977). These include micro-climatic factors (degree of illumination, humidity, aspect), substrate factors, both physical (age, corrugation and sloughing of the bark, inclination of the surface) as well as compositional (pH, nutrient status, presence of tannins etc., moisture retention properties), and site factors (age of forest, level of pollution). No quantitative data on the role of any of these factors in Tasmanian rainforest are presently available and the following discussion is based entirely on qualitative observations. However, good evidence for the assertions made is provided by the detailed studies discussed in subsequent sections of this thesis.

In Tasmanian rainforest, the major factors determining the character of the lichen flora appear to be the availability of light, light-related factors such as temperature and exposure to desiccation, moisture availability and the physical properties of the substrate. Higher plant floristics and the age of the forest are also important but can mostly be interpreted in terms of light and substrate characters. No information is available on the role of bark chemistry. Air pollution is not important due to the overall remoteness today of most Tasmanian rainforest from areas of industrialisation and settlement. The main exception is the Queenstown area (western Tasmania) where c. 20,000 ha have been totally devastated by tree-felling, burning and subsequent pollution from a copper smelter.

1. Light and related factors

Changes in the lichen flora occur in response to changes in light. These may be due directly to differences in light intensity or wavelength, or to additional related factors such as exposure to desiccation or fluctuations in temperature. Minor openings in the

forest canopy caused by windthrow, track cutting or death of individual trees often cause a local, temporary increase in diversity rather than a depletion of the lichen flora due to drying out. However, some shifts in relative dominance may occur towards more drought-resistant species (Rundel et al. 1979). For example, Pseudocyphellaria colensoi, P. coronata, P. argyracea aggr. and P. ardesiaca may displace the shade-tolerant species P. subvariabilis and P. dissimilis, whereas Sphaerophorus melanocarpus is replaced by S. ramulifer or S. tener. A marked vertical zonation in the lichen flora is clearly apparent on individual trees in many forests and this is also attributed partly to changes in the light regime (see part IIIB for detailed discussion). There is also evidence that fluctuation in environmental conditions is of greater benefit to lichens as a whole than the maintenance of constant conditions (Pearson 1969). Consequently, the peak of diversity and luxuriance is frequently attained not in climax rainforest vegetation with its (often) closed canopies and dark understoreys but in more open seral communities or along the forest margins.

Within the forest, penetration of sunlight is patchy. Most forests have evergreen, closed canopies and the illumination of particular trunk faces depends not on their north-south orientation but on the chance alignment of suitable gaps in the canopy and understorey. Such "light spots" are often of very short duration and migrate across the forest in a seemingly random fashion during the day as well as seasonally. Their impact is likely to be influenced by other factors such as the moisture content of the lichens during the period of illumination. In general, the influence of such light spots appears minor, although their presence may help to explain the rare persistence of some light-loving species at low levels within the forest.

## 2. Moisture

Moisture availability varies in different forest microhabitats. Permanently moist recesses such as drainage channels or gaps between overlain fallen trees are usually very shaded and are inhabited by bryophytes only. However, observations from permanently wet but well-lit rainforest in the spray zone of a waterfall suggest that excessive moisture is unsuitable for all but a few lichens, e.g. Leptogium victorianum and L. limbatum. Similarly, terricolous or

saxicolous habitats which are very dry, e.g. underhangs along river banks, road cuttings or steep escarpments, also have an impoverished lichen flora. This consists mainly of Lepraria incana but Psilolechia lucida may be locally abundant, particularly on exposed roots.

Obvious moisture differences may form on tree trunks in rainforest, not in response to aspect but as a product of leaning stems. For example, trunks of Nothofagus cunninghamii are commonly inclined up to 30° away from the vertical, possibly due to the bending of saplings in early life towards gaps in the canopy. In older, larger trees, this growth habit leads to the development of moist and dry sides with a concomitant zonation in lichen habitats. Key species of the driest surfaces include Sagenidium molle, Lecanactis abietina, Arthonia spp. and species of the Caliciales. The flora of the wet trunk face includes species of Sphaerophorus, particularly S. insignis and S. melanocarpus, Cladia aggregata, Pilophorus conglomeratus and an abundance of bryophytes.

A wet/dry zonation is seldom observed on other tree species in Tasmanian rainforest because they are rarely inclined or attain sufficiently large diameters. A tendency to develop "dry" communities has been observed on large-diameter Eucryphia lucida and Phyllocladus asplenifolius but these communities never attain the complexity of those found on Nothofagus. Analogous hydrophobous communities have been reported from Nothofagus in New Zealand rainforest (Mark et al. 1964), Pseudotsuga in the USA (Pike et al. 1975) and Quercus in Britain (James et al. 1977).

## 3. Substrate

Most rainforest lichens (c. 97%) are epiphytes and the variation in the roughness, stability and moisture-holding capability of tree barks is responsible for many lichen distribution patterns. Foliage size and branching pattern of the host tree are also important. The characteristics of 32 rainforest phorophytes are summarised in Table 2. No data on the pH at the bark surface are available but measurements of the pH of pulverised bark samples indicate that the bark of rainforest trees is acidic and values of pH 4 - 5.7 have been recorded (see Table 3). Similarly, there is no information on bark chemistry but the similarities in the lichen floras of Atherosperma and Tasmannia, both of which have aromatic

Table 2. Characteristics of some of the more common rainforest phorophytes.

| SPECIES | FAMILY | HABIT | BARK TEXTURE | LEAF SIZE* CLASS |
|---|---|---|---|---|
| Acradenia frankliniae | Rutaceae | highly branched shrub | smooth | microphyll |
| Agastachys odorata | Proteaceae | shrub or low tree | smooth | microphyll |
| Anodopetalum biglandulosum | Cunoniaceae | highly branched shrub or small tree | smooth | microphyll |
| Anopterus glandulosus | Escalloniaceae | tall shrub | smooth | notophyll |
| Archeria eriocarpa / A. hirtella | Epacridaceae | low to medium shrub | thin, fibrous | nanophyll |
| Atherosperma moschatum | Monimiaceae | tall tree | smooth, sometimes ± papillate with age | microphyll |
| Athrotaxis selaginoides | Taxodiaceae | tall tree | thick, spongy and fibrous | nanophyll |
| Cenarrhenes nitida | Proteaceae | tall shrub or low tree | smooth | notophyll |
| Coprosma nitida | Rubiaceae | low to medium shrub | thin, smooth or fissured | nanophyll |
| Cyathodes juniperina | Epacridaceae | medium to tall shrub | thin, fibrous | nanophyll |
| Dicksonia antarctica | Dicksoniaceae | tree fern | fibrous | megaphyll |
| Eucalyptus delegatensis/ E. obliqua/ E. regnans | Myrtaceae | very tall tree | thick, spongy and fibrous | notophyll-megaphyll |
| Eucalyptus gunni/ E. subcrenulata | Myrtaceae | tall tree | smooth, decorticating above a rough stocking | microphyll-notophyll |
| Eucryphia lucida | Eucryphiaceae | tall tree | smooth, sometimes ± papillate with age | microphyll |
| Eucryphia milliganii | Eucryphiaceae | medium tree | smooth | nanophyll |
| Lagarostrobos franklinii | Podocarpaceae | tall tree | smooth, becoming warty but not decorticating | nanophyll |
| Leptospermum lanigerum | Myrtaceae | medium tree | thick, papery | nanophyll |
| Melaleuca squarrosa | Myrtaceae | medium tree | very thick, spongy & papery | nanophyll |
| Notelaea ligustrina | Oleaceae | low tree | smooth | microphyll |
| Nothofagus cunninghamii | Fagaceae | tall tree | smooth, becoming rough, decorticating | nanophyll |
| Nothofagus gunnii | Fagaceae | deciduous low tree or shrub | smooth, becoming rough, fissured | nanophyll |
| Olearia argophylla | Compositae | low spreading tree | thick, fibrous | notophyll |
| Phyllocladus aspleniifolius | Podocarpaceae | tall tree | smooth, becoming thick, warty and fissured | microphyll |
| Richea pandanifolia | Epacridaceae | tall shrub or low tree | thin, fibrous | megaphyll |
| Tasmannia lanceolata | Winteraceae | shrub or small tree | smooth | microphyll |
| Telopea truncata | Proteaceae | tall shrub or small tree | smooth | notophyll |
| Trochocarpa cunninghamii | Epacridaceae | low shrub | smooth | nanophyll |
| Trochocarpa gunnii | Epacridaceae | tall shrub | smooth | nanophyll |

* nanophyll: <2.5 cm long; microphyll: 2.5-7.5 cm long; notophyll: 7.5-12 cm long; megaphyll: >12 cm long (after Webb et al. 1976)

Table 3. pH of pulverised bark samples from some rainforest trees and shrubs*.

| SPECIES | pH |
|---|---|
| Anopterus glandulosus | 4.5 |
| Atherosperma moschatum | 5.2 |
| Athrotaxis cupressoides | 4.2 |
| Coprosma nitida | 4.4 |
| Eucalyptus subcrenulata | 5.7 |
| Nothofagus cunninghamii (young, smooth) | 5.0 |
| Nothofagus gunnii | 5.0 |
| Phyllocladus aspleniifolius (old, rough) | 4.0 |
| Tamannia lanceolata | 4.9 |
| Telopea truncata | 5.0 |
| Trochocarpa gunnii | 4.7 |

* Bark samples were oven-dried, cleaned of epiphytes, pulverised and dissolved at a rate of 2.5 g to 50 ml. distilled $H_2O$.

bark, suggest that this might be a profitable avenue for a future study.

The majority of tree species in rainforest have smooth bark when young and are usually first colonised by crustose lichens such as Thelotrema lepadinum, Coccotrema cucurbitula, Opegrapha stellata and Catillaria spp., as well as by the macrolichens, Pseudocyphellaria subvariabilis and Psoroma microphyllizans. As the host tree ages, a diversification of the lichen flora begins which depends on the particular physical properties of the substrate. For example, on trees which retain a smooth bark, the pioneer species will usually be maintained as the tree ages, although additional species will also become established. However, on Nothofagus cunninghamii, the bark fissures and cracks, creating new microhabitats, and the pioneer species are shed with plates of bark or are overgrown, mainly by bryophytes and macrolichens.

Several lichens show distinct host-preferences but, in most cases, this is interpretable in terms of a preference for a particular feature of the bark rather than for the host itself. For example, Wawea fruticulosa is best developed on myrtaceous trees or Richea pandanifolia (Henssen & Kantvilas 1985) and appears to favour fibrous or thick papery bark which retains moisture; Dimerella lutea occurs most commonly on Dicksonia antarctica, Cyathodes juniperina and other species with fibrous bark; Phlyctella subuncinata, Catillaria kelica and several other crustose lichens display a preference for smooth bark such as that of Atherosperma, Cenarrhenes or Tasmannia; species of Sphaerophorus are best-developed on moist, rough bark, typically on Nothofagus cunninghamii or Phyllocladus aspleniifolius; species of Cladonia are most common on thick, spongy bark such as that of Eucalyptus or Athrotaxis. Cases of host preference seem to be more common amongst the crustose lichens but this is to be expected given their more intimate contact with the substrate. For example, they are likely to be more influenced by bark pH and chemistry than would the larger species which often overgrow epiphytic bryophytes instead of being attached directly to the bark substrate.

Despite the instances of substrate preference listed here, few lichens are absolutely restricted to a particular host, although one exception is Gymnoderma melacarpum which, when epiphytic, is totally confined to Eucalyptus. When viewed across their entire range, the

differences in the lichen floras of different tree species tend to take the form of variations in relative amounts of a lichen species rather than the absolute presence or absence of a species (see also p.81).

## 4. Floristics

The floristic composition of phanerogams in forest vegetation is a major contributor to the character of local habitats, but due to the poor host-specificity shown by rainforest lichens, the presence of a particular woody species is often less critical than the presence of certain physical characteristics. Similar trends have been noted by Pike et al. (1975) and Hale (1955) in North American forests, and by Kershaw (1964) who commented on the importance of canopy characteristics. In Tasmanian rainforest, differences in the canopy in the general proportions of nanophylls (leaves < 2.5 cm long, Webb et al. 1976), characteristic of Nothofagus, to microphylls (leaves 2.5-7.5 cm long), characteristic of Atherosperma, Phyllocladus and Eucryphia lucida, can be related to differences in the lichen flora. The presence or absence of an understorey and the nature of its foliage also affects the lichen flora. Tree ferns (Dicksonia antarctica), microphyll shrubs (e.g. Anodopetalum) and notophyll shrubs (leaves 7.5-12 cm long) (e.g. Anopterus and Cenarrhenes) produce a much shadier, low-level layer in the forest than do finer-leaved nanophyll shrubs (e.g. Trochocarpa and Archeria). Since Tasmanian forests consist almost entirely of evergreen species, there is a more or less constant density for each stratum of the forest throughout the year.

Some general features of the lichen flora as determined by the floristics and structure of the rainforest community are presented below.

### (a) Tall (c. 30 m), well-formed lowland forests (lowland thamnic and callidendrous rainforest)

This group includes communities dominated by Nothofagus cunninghamii where Atherosperma moschatum, Eucryphia lucida or Phyllocladus aspleniifolius are subdominant or co-dominant. The canopy is often closed and small trees, shrubs or tree ferns may be present below. The high proportion of microphylls in the forest and the denseness of the canopy results in poor light penetration through

the forest. Consequently the lichen flora, at least at lower levels, is depauperate, similar to the situation in tropical rainforest (P.M. Jorgensen pers. comm.).

Ground-dwelling species are virtually absent with the exception of Peltigera dolichorhiza and Pseudocyphellaria dissimilis which may be locally common on logs and buttresses, extending onto tree trunks in the most shaded, humid sites. A wide range of epiphytic habitats is provided by the various ages and textures of the different substrates available. Sphaerophorus - bryophyte communities and Sagenidium molle "dry" communities occur on rough-wet and rough-dry bark respectively and often attain their greatest complexity in these forests. Communities dominated by Pseudocyphellaria subvariabilis, Psoroma microphyllizans and various crustose lichens such as Thelotrema lepadinum, Bacidia weymouthii and Megaloblastenia marginiflexa predominate on smooth bark. Cover and diversity of lichens increase with increased height up the tree trunks and these forests offer the best examples of vertical zonation in the lichen flora (see part IIIB).

(b) Low (< 20 m) forests with dense understoreys (implicate rainforest)

These communities are confined to western and south-western Tasmania. They have low, broken canopies and their understorey is dense and scrubby, forming a tangle of horizontal and ascending, chiefly small-diameter stems which tend to overgrow the forest floor. There is a paucity of old large diameter trunks or ground habitats and hence little variation in the substrates available. Vertical zonation is also poor and little change in lichen cover and diversity occurs with height.

The richness of the lichen flora appears to depend on the height of the scrubby understorey and the type of foliage present. When this stratum is about 5-10 m tall and microphyllous (composed of Agastachys, Andopetalum etc.), the trunks are wet and mainly colonised by leafy hepatics and blue-green algae. Lichens are sporadic and poorly developed, particularly the crustose species. However, where the closed layer is only 2-5 m tall and dominated by nanophyll species such as Trochocarpa gunnii or Archera hirtella, the lichens tend to be better developed and very lush growths of species

of Pseudocyphellaria and Psoroma may be present on the abundant leafy twigs.

Several lichens are characteristic of this type of rainforest: Sphaerophorus scrobiculatus, Roccellinastrum neglectum, Siphula spp., Wawea fruticulosa and Pertusaria sp.2. More wide-ranging species such as Sphaerophorus melanocarpus, S. tener and Pseudocyphellaria subvariabilis are also common and increase in abundance where the forest is better formed and less scrubby.

(c) High altitude rainforests

(i) Callidendrous and thamnic communities. These are closed forests which occur above c. 750 m and are lower in stature (up to 18-22 m tall) than their lowland counterparts. They contain few characteristic lichens although exceptions include Conotremopsis weberiana, Cetraria chlorophylla and Phyllopsora congregans. However, these species are rarely common. Instead, the forests feature an overall increase in luxuriance and abundance of all lichens (at the expense of bryophytes), a general diversification, particularly in Menegazzia and Psoroma, and a shift in relative importance towards species apparently more tolerant of drier, less shady conditions. For example, Sphaerophorus ramulifer and S. tener increase in abundance at the expense of S. melanocarpus and S. insignis. In addition, there is often a ground lichen flora of Cladina confusa, Cladonia scabriuscula and other Cladonia species. The lichen floras of many high altitude forests also feature minor occurrences of species from subalpine and alpine habitats, e.g. Menegazzia globulifera and M. subbullata. High altitude callidendrous forests are extremely simple with respect to their vascular flora and mostly consist of a pure Nothofagus cunninghamii canopy. Understorey species are very widely separated so that gaps in the canopy allow uninterrupted light penetration to the forest floor. High altitude thamnic forests have a more diverse flora of trees and shrubs but the advantage of increased substrate variety is negated by the resultant shade effect. This is highlighted by the distribution of the shade-loving lichen Pseudocyphellaria subvariabilis. This species is uncommon and confined to the ground or the most sheltered, wettest microhabitats in high altitude callidendrous forests. However, in the shadier high altitude thamnic forests, it retains its position as a dominant

rainforest epiphyte. The lichen communities of high altitude callidendrous rainforest are described in part IIIC.

(ii) Implicate forests. These forest communities tend to resemble their lowland counterparts although they may be richer in species of Psoroma and Menegazzia. However, communities containing Nothofagus gunnii are often noticeably impoverished with respect to macrolichens, despite the fact that this tree is winter deciduous and so permits uninterrupted light penetration for at least part of the year. Some crustose lichens, e.g. Megalospora lopadioides and Mycoblastus sp.1, may be particularly abundant in such forests.

(iii) Open montane forest. These forests have been poorly studied. Lichen diversity is generally low and the dominant tree species, Athrotaxis cupressoides, is a poor substrate. Nothofagus gunnii is often an important undershrub but supports few epiphytes. Most of the twiggy undershrubs are also poorly colonised although they may support communities dominated by species of Menegazzia (M. testacea and M. subbullata) and Hypogymnia (H. lugubris). The forests do not occur in extensive stands and contain many extraneous lichen species from adjacent alpine heathland.

(d) Rainforest dominated by eucalypts ("mixed forest")

Eucalypts may occur as widely-spaced emergents over rainforest but do not contribute to a significant shade effect, although they may cause openings in the rainforest canopy when they or their dead limbs fall. Some "mixed forests", particularly in north-western Tasmania, have a very open understorey with a considerable low-level twig lichen flora dominated by Psoroma euphyllum, Nephroma australe and Pseudocyphellaria spp. Other species characteristic of such forests include Menegazzia eperforata and Bactrospora spp. which occur on mature Nothofagus.

Eucalypts themselves, particularly E. obliqua, E. regnans and E. delegatensis, are usually poor lichen substrates although Gymnoderma melacarpum, Cladia schizopora and to a lesser extent Cladonia squamosula are mostly confined to their stockings of fibrous bark. However, some species of the Eucalyptus subgenus Symphyomyrtus, particularly the high altitude species, E. gunnii and E. subcrenulata, may be excellent substrates for lichens, with communities containing species of Nephroma, Collema, Pseudocyphellaria, Psoroma and Leptogium on their buttresses.

(e) Forests dominated by conifers.

Conifers are an important component of some rainforest communities, with those containing Athrotaxis selaginoides and Lagarostrobos franklinii being of particular interest. Both of these trees may attain great ages and are extremely fire sensitive (Kirkpatrick 1977). Ogden (1978) records ages of 900 - 1300 years for Athrotaxis and in excess of 2200 years for individuals of Lagarostrobos. Thus it may be inferred that forests containing mature individuals of these species represent habitats where disturbance from fire has been absent for at least several hundred years. However, the forests show no particular lichenological features despite their great age. Neither conifer is a particularly good substrate for epiphytes. In situations where either species occurs as an emergent over implicate rainforest or as an occasional tree in high altitude or lowland forests, the basic features of the lichen flora as determined by the rest of the vegetation remain unaltered and the conifers apparently contribute nothing. Where Athrotaxis forms the dominant canopy, its effects are analogous to those of eucalypts in "mixed forest". Its broken, sparse canopy causes only minor shading and the lichen flora is determined by the characteristics of the lower strata of vegetation. It may be very lush and diverse but is consistent with similar communities where Athrotaxis is absent. However, where Lagarostrobos is the dominant, it usually forms a very dense, closed canopy so that the entire lichen flora is reduced to only occasional, impoverished individuals.

**Fragmentation of rainforest stands**

There is some evidence that the fragmentation of rainforest stands has deleterious effects on the lichen flora, not unlike those described by Rose (1976) in England. Small scale disturbances, e.g. clearings caused by track cutting, have only a minor effect since they are buffered by the remaining forest edging the disturbed site. Some species may be temporarily lost due to the removal of special habitats but others persist on rocks and logs. However, the surrounding undisturbed hinterland acts as a repository of lichen diaspores which can reinvade the regenerating rainforest vegetation.

Many rainforest lichens display an amazing resilience to disturbance and the removal of the rainforest habitat. Surviving

thalli of Sphaerophorus spp., Pseudocyphellaria spp., Megalospora lopadioides and other lichens have been encountered on rocks in marginally fire-protected outcrops in sedgeland-heath in south-western Tasmania and in land cleared for agriculture in the North-East. However, the long-term survival of these individuals is doubtful and they will most likely be eventually destroyed by a wildfire or succumb to the rigours of an exposed habitat.

Large scale disturbance such as clear-felling in forestry operations has a more drastic effect on the lichen flora. Firstly, the distance from an undisturbed source of diaspores is greatly increased and this may hamper the re-establishment of some species. More importantly, clear-felling is usually followed by burning which is not only destructive in itself but also reduces most substrates to charcoal and scorched earth. These are unsuitable for recolonisation by rainforest lichens with the exception of Peltigera dolichorhiza. It is customary for burnt sites to be seeded with species of Eucalyptus which, when young, are very poor substrates and create a dense shady understorey beneath a completely closed canopy. Occasional rainforest trees often regenerate in these "managed" forests but they are unlikely to attain sufficiently large size or diversity of micro-habitats to support well-developed epiphytic communities before the next cycle of clear-felling begins. This is particularly the case with "old trunk" species such as Sagenidium molle, Pilophorus conglomeratus and species of Sphaerophorus, Arthonia, Lecanactis and Micarea. No regeneration of lichens whatsoever has been observed where native forests have been replaced with plantations of Pinus radiata. At present, clear-felling in pure rainforest is not a widespread practice in Tasmania but it occurs frequently in "mixed forest" or where small stands of rainforest occur within eucalypt forest. However, pressures on rainforest can be expected to increase as the sclerophyll forest resource dwindles.

The early effects of fragmentation of rainforest are already evident in Tasmania. In relict, isolated rainforest stands on the Eastern Tiers and Tasman Peninsula, the lichen flora lacks many typical rainforest species such as those listed above. Furthermore, many of the species present are often poorly developed and infertile. Instead, lichens more typical of the surrounding sclerophyll forest, e.g. Menegazzia subpertusa, Parmelia perlata, P. pruinata, Collema leucocarpum and Ramalina spp., become increasingly abundant.

A similar situation is evident in the relict rainforests in Victoria. In addition to the presence of "weedy" sclerophyll forest lichens, the lichen flora of these stands is relatively impoverished. A number of lichens which are common and well-developed in Tasmania are either absent (e.g. Sagenidium molle) or rare and seldom fertile (e.g. Pilophorus conglomeratus) in Victoria. Conversely, the apparent concentration of rare rainforest species in north-western Tasmania (see p.59) may be due to the fact that the most extensive tracts of rainforest in Tasmania are located there.

## B. THE VERTICAL DISTRIBUTION OF RAINFOREST LICHENS

### Introduction

The vertical zonation of epiphytes has been briefly reported in many surveys of forest lichens, particularly in North America. Such studies have usually been confined to the lowermost levels of the forest and have compared lichen floras from the bases of trees to those from trunks at breast height (e.g. Case 1977, Culberson 1955, Brodo 1961). Few workers have attempted to overcome the many logistic problems entailed in examining the entire epiphytic flora of a tree. Successful studies include those of Kershaw (1964), Harris (1971a) and McCarthy (1978) in the British Isles and Gough (1975) in North America which were undertaken by climbing trees. Hale (1952) in North America and Ashton and McRae (1970) in Australia studied recently-fallen trees whilst Yarranton (1972) and Hale (1965) in North America worked on trees felled specifically for the purpose. A more innovative approach was employed by Pike et al. (1975) who used mountain climbing techniques to scale Douglas Firs, and by Hinds (1970) who used linesman's equipment to climb aspens.

The results of these studies illustrate several features of vertical zonation:

(a) The zones are broadly overlapping and are usually comprised of widely-distributed species. The zones differ more in the relative amounts of species present than in the presence or absence of particular species.

(b) The zones are not static and may vary in extent and position from one tree species to the next or from place to place, depending on the characteristics of both the substrate and the site.

(c) Unlike bryophytes which favour mesic conditions, lichens tend to be more successful in xeric conditions (Hoffman and Kazmierski 1969). Height up a tree almost invariably represents a shift towards xeric conditions and hence usually features an increase in cover and diversity of lichens at the expense of bryophytes. However, all epiphytes usually decline immediately beneath the canopy.

Earlier literature on vertical zonation has been reviewed by Barkman (1958) who also discussed many of the habitat factors which

could be responsible for lichen zonation. These factors include bark characteristics such as water-holding capacity and rate of water-absorption (which tend to decrease with tree height) and climatic factors such as light intensity, evaporation, temperature and wind, all of which increase with height (Barkman op. cit.). Harris (1971a) suggested that water availability was an important controlling factor and, in subsequent physiological experiments (Harris (1971b), demonstrated that light intensity was also important. Furthermore, he found that different species as well as ecotypes of a single species were physiologically adapted to their environment. Thus lichens from shaded habitats had a higher rate of carbon assimilation at low light levels than did tree-top forms. Similarly, the optimum water content for photosynthesis was lower for lichens from xeric habitats in the tree canopy than that for lichens from more mesic, basal habitats. A subsequent simulation experiment (Kershaw and Harris 1971) indicated that the evaporation gradient was more important than the light gradient. Ashton and McRae (1970) also found that basal species were more sensitive to the effects of high temperature and desiccation than were canopy species.

Change in bark pH has also been advanced as a possible explanation for lichen zonation although its correlation with height is inconclusive. Barkman (1958) and Kershaw (1964) found that bark pH decreased with height, whereas Kalgutkar and Bird (1969) and Gough (1975) reported that in selected conifers it showed no relationship to height. Kershaw (op. cit.) showed that the distributions of Parmelia sulcata and Hypogymnia physodes were correlated with pH (positively and negatively respectively) and sought to explain their zonation accordingly. He also examined the ash and phosphorus content of tree bark but found no correlation between this and lichen distributions.

The effect of aspect on vertical distribution has been examined by Billings and Drew (1938) who found that vertical zonation was best developed on moister aspects, and by Pike et al. (1975) who distinguished discrete zones which were determined by aspect. However, Yarranton (1972) found no correlation between the effects of height and aspect whilst Sheard and Jonescu (1974) felt that aspect was generally of secondary importance, except where moisture was limited.

Other factors which have been found to affect lichen distributions include the age, composition and canopy density of the forest. These factors are manifest both at the one level (Jesberger and Sheard 1973) and vertically (Szczawinsky 1953). Yarranton (1972) also found that distance to the nearest tree was important.

Very few studies have been undertaken to examine lichen distribution and zonation in evergreen cool temperate rainforest, e.g. see Mark et al. (1964) in New Zealand forests and Ashton and McRae (1970) in forests in mainland Australia. Canopy characteristics are particularly important in such forests because their shading effects are more or less constant throughout the year (see p.66). The low-level lichen floras of these forests tend to be depauperate but a marked change in the lichens occurs with increased height.

The present study aims to examine the vertical distribution of lichens in cool temperate rainforest in Tasmania, with particular reference to the effects of the host tree species. A preliminary classification of the lichen flora is also undertaken.

## Methods

### 1. The study area

The study area was located at Sumac Road, Spur 2, south of the Arthur River in north-western Tasmania, an area with an annual rainfall of 1500-2000 mm. The site consisted of 0.25 ha of lowland thamnic rainforest (altitude = 170 m) and represented a portion of a 20 ha coup to be logged for regeneration studies by the Forestry Commission.

The forest was approximately 30 m tall with Nothofagus cunninghamii dominant and Eucryphia lucida subdominant. Other species, occurring as scattered, low trees, included Cenarrhenes nitida, Phyllocladus aspleniifolius and Atherosperma moschatum. The understorey was open above a dense ground layer of the fern, Blechnum wattsii, interspersed with local patches of the low shrub, Trochocarpa cunninghamii.

Most individuals of Nothofagus and Eucryphia had damaged crowns where the main axis had snapped and upwards growth continued by a number of laterals. These breaks usually occurred at 20-23 m height on Nothofagus and 13-17 m on Eucryphia. The other tree species, being lower in stature, mostly lacked this feature. Details of bark and

foliage characteristics of these species are given in Table 2. The distinctive branching patterns of the trees are illustrated in Figure 11. Several Nothofagus trees were also affected by a fungal pathogen (Chalara sp.). This fungus slowly kills the infected trees which remain standing as they decay. Dead trees scattered through the forest produced gaps in the canopy both directly as well as by periodically dropping large limbs which damaged young regrowth. A map showing the relative positions and girths of all the trees and shrubs in the forest is given in Figure 11.

2. Host trees

Thirty-four trees for study were chosen subjectively to include a range of heights and girths of each species present (see Table 4). These included 15 Nothofagus, 11 Eucryphia, 4 Phyllocladus, 3 Cenarrhenes and 1 Atherosperma. The numbers of each species sampled reflects their relative abundance in the forest. The trees were felled by a professional logger, with felling staggered across several days. Some dislodgement of lichens during felling (cf. Pike et al. 1975) occurred although this was not considered critical as some portion of the thallus always remained attached. Three very old trees (not included in Table 4) shattered on impact with the ground and could not be sampled.

3. Sampling

Field work was undertaken as the forest coup was being logged and the forester's strict logging schedule dictated the need for rapid data gathering. Thus only presence/absence data were recorded. The emphasis of the study was on macrolichens, enabling the majority of identifications to be done on site (although many specimens were collected for checking and/or later determination). Records of species of the Graphidaceae were combined. Measurements of aspect and bark characteristics were not included in the study because of time constraints although these may have been invaluable in explaining lichen distributions.

Each tree was considered in terms of three general components: a trunk, lateral branches, and twigs. The trunk was defined as the more or less vertical axis, $\geq$ 3 cm diameter. Trunk records consisted of lists of lichens present within each metre of height irrespective of diameter. Where the trunk forked into two or more axes, sampling

Table 4. Species, reference numbers, heights and diameters at breast height of 34 trees studied at Sumac Road.

| TREE NO. | SPECIES | HEIGHT (m) | DIAMETER (cm) |
|---|---|---|---|
| N1 | Nothofagus cunninghamii | 18 | 25 |
| N2 | N. cunninghamii | 22 | 32.5 |
| N3 | N. cunninghamii | 29 | 81 |
| N4 | N. cunninghamii | 25 | 40 |
| N5 | N. cunninghamii | 27 | 75 |
| N6 | N. cunninghamii | 15 | 19 |
| N8 | N. cunninghamii | 27 | 50 |
| N9 | N. cunninghamii | 26 | 63 |
| N10 | N. cunninghamii | 26.5 | 66 |
| N11 | N. cunninghamii | 27 | 59 |
| N12 | N. cunninghamii | 29 | 70 |
| N14 | N. cunninghamii | 26 | 41 |
| E15 | Eucryphia lucida | 22 | 35.5 |
| E16 | E. lucida | 24 | 30 |
| E17 | E. lucida | 25 | 47 |
| E19 | E. lucida | 27 | 46 |
| E20 | E. lucida | 24 | 47 |
| N21 | Nothofagus cunninghamii | 22 | 52 |
| C22 | Cenarrhenes nitida | 14 | 17.5 |
| C23 | C. nitida | 12 | 15 |
| A24 | Atherosperma moschatum | 12 | 10 |
| N25 | Nothofagus cunninghamii | 15 | 12 |
| P26 | Phyllocladus aspleniifolius | 8 | 7 |
| E27 | Eucryphia lucida | 22.5 | 35 |
| E28 | E. lucida | 17 | 16.5 |
| N29 | Nothofagus cunninghamii | 27 | 35 |
| E30 | Eucryphia lucida | 26 | 33 |
| E31 | E. lucida | 19.5 | 23 |
| P32 | Phyllocladus aspleniifolius | 21 | 34 |
| C33 | Cenarrhenes nitida | 14 | 20 |
| P34 | Phyllocladus aspleniifolius | 16 | 17 |
| P35 | P. aspleniifolius | 15.5 | 17.5 |
| E36 | Eucryphia lucida | 20 | 19.5 |
| E37 | E. lucida | 25 | 56 |

Table 5. Subdivision of sample numbers from the Sumac Road study (total = 981).

| | Notho-fagus | Eucryphia | Phyllo-cladus | Cenarr-henes | Athero-sperma |
|---|---|---|---|---|---|
| trunk | 392 | 295 | 62 | 51 | 10 |
| lateral branch | 26 | 8 | - | - | - |
| twig | 67 | 39 | 22 | 8 | 1 |

continued by treating each axis as a separate trunk of the one tree. A lateral branch was defined as a limb ≥ 3 cm diameter which did not form a "leader" or new growth axis. Lateral branches were arbitarily selected, recording their height and diameter at the point of insertion on the trunk. The entire branch to the 3 cm diameter point was considered as a unit, irrespective of length or branching (4 m was the maximum length). Twigs were defined as branchlets < 3 cm diameter and were usually 1 - 2 m long. One twig record per axis or lateral was derived from the combined lichen floras of up to 10 branchlets. A total of 981 samples were recorded (see Table 5).

### 4. Analysis of data

Data analyses consisted of two approaches. The first was a direct gradient analysis and involved an evaluation of the performance of individual species as well as species diversity using height as the direct gradient. The second approach entailed the use of numerical techniques. These included an ordination method, Detrended Correspondence Analysis, using the computer program DECORANA (Hill 1979a) for indirect gradient analysis, and the classification method, Two-way Indicator Species Analysis, using the computer program TWINSPAN (Hill 1979b). The two methods are considered complementary (Gauch and Whittaker 1981) and are briefly outlined in Appendix 2.

## Results and discussion

### 1. Lichens recorded

Seventy-seven lichen species were recorded in the study area. These included 56 macrolichens and 21 of the most common or distinctive crustose species (see Table 6). The lichen flora was almost entirely epiphytic, although occasional gaps in the ground fern layer supported communities of Peltigera dolichorhiza and Pseudocyphellaria dissimilis. Apart from the presence of some rare species which occur mainly in north-western Tasmania, e.g. Bactrospora dryina, Heterodermia microphylla, Lopadium disciforme, Menegazzia inactiva, M. minuta and Psoroma euphyllum, the lichen flora is typical for lowland thamnic rainforest (see p. 66).

Table 6. Lichens recorded in the Sumac Road study area.

Arthothelium sp. 1
"Asteristion" lamelliferum
Austroblastenia pauciseptata
Bacidia sp. 1
Bactrospora dryina
Catillaria kelica
Cladia aggregata
Cladonia ochrochlora
Coccotrema cucurbitula
Collema fasciculare
C. laeve var. laeve
C. subconveniens
Degelia durietzii
Dictyonema sericeum
Graphis scripta
G. insidiosa
Heterodermia microphylla
Hypogymnia turgidula
Lecidea ceroplasta
L. laeta
Leioderma amphibolum
L. pycnophorum
Lepraria incana
Leptogium victorianum
Lopadium disciforme
Menagazzia inactiva
M. minuta
M. nothofagi
M. platytrema
M. retipora
M. subpertusa
M. ultralucens
M. weindorferi
Micarea prasina aggr.
Mycoblastus sp. 1
Nephroma australe
Ochrolechia sp.
Pannoparmelia angustata
Parmelia cunninghammii
P. protosulcata
P. pruinata
P. cf. revoluta
P. sinuosa
P. subglabra
P. tenuirima
Parmeliella nigrocincta aggr.
Peltigera dolichorhiza
Pertusaria nothofagi
Phaeographis exaltata
Physma sp.
Pilophorus conglomeratus
Pseudocyphellaria ardesiaca
P. argyracea aggr.
P. colensoi
P. coronata
P. delisea
P. dissimilis
P. faveolata aggr.*
P. rubella
P. subvariabilis
Psoroma durietzii
P. euphyllum
P. leprolomum
P. microphyllizans
P. pholidotoides
P. soccatum
Sagenidium molle
Schismatomma sp.
Sphaerophorus insignis
S. melanocarpus
S. ramulifer
S. tener
Sticta stipitata
Thelotrema lepadinum
Usnea arida
U. rubicunda
species A

* At the time of the study, the clarification of this aggregate by Galloway et al. (1983) was unavailable. Both P. billardieri and P. faveolata were present in the study area but are collectively referred to under the latter name throughout this section.

## 2. Host specificity of the lichen flora

Percentage frequencies of the occurrence of each lichen species on the different hosts are given in Table 7. Only qualitative assessments (rare, absent, present) are given for the minor trees due to low numbers of samples. The most frequent lichens on Nothofagus are Pseudocyphellaria delisea (69.4%), Sphaerophorus insignis (56.8%) and S. tener (43%). On Eucryphia, the most frequent lichens are Psoroma microphyllizans (76%), Pseudocyphellaria delisea (73.1%) and P. subvariabilis (55.3%). Whilst many species show a preference for a particular substrate, few are confined to a single host. Of those which are, none are common species and only Menegazzia minuta (found on Eucryphia) has never been recorded from another phorophyte elsewhere.

65 species were recorded from Nothofagus, 56 from Eucryphia, 28 from Cenarrhenes, 44 from Phyllocladus and 11 from Atherosperma. Although these figures are partly related to the numbers of sampled individuals of each phorophyte, morphological differences between the trees also serve to explain many of the differences in their lichen floras. Nothofagus is tallest, with a loosely-branched crown and fine foliage. Consequently, it possesses more exposed canopy habitats than those found in the relatively shaded, dense crowns of Eucryphia or the low trees. Several lichens apparently preferential to Nothofagus, e.g. Pertusaria nothofagi, Parmelia spp. and Menegazzia spp., are all species of exposed canopy twigs. The development of rough bark also accounts for the preference of some lichens for Nothofagus, e.g. Sphaerophorus spp., as does the development of dry trunk surfaces, e.g. Sagenidium molle. Thus the greater diversity of lichens present on Nothofagus can be explained by the greater diversity of substrates and habitats available [cf. Kalgutkar and Bird (1969) for Canadian conifers].

Eucryphia lacks any obviously unique habitats. Its higher frequencies of epiphytes of smooth bark, e.g. Sticta stipitata and some species of Psoroma, may be simply a reflection of the greater availability of smooth bark for colonisation. Some lichens, e.g. Collema subconveniens, are mainly muscicolous and it is possible that the distribution of such species is linked with their associated bryophytes. Bryophytes appear superficially different on the different hosts although no published data are available.

Table 7. Percentage frequency of lichens on each host tree species (x represents presence on tree species with low numbers of samples).

| | Nothofagus | Eucryphia | Cenarrhenes | Phyllocladus | Atherosperma |
|---|---|---|---|---|---|
| Arthothelium sp. 1 | - | - | - | - | x |
| Asteristion lamelliferum | 0.2 | 0.9 | x | x | - |
| Austroblastenia pauciseptata | 4.1 | 0.3 | - | rare | - |
| Bacidia sp. 1 | 2.5 | 0.6 | - | - | - |
| Bactrospora dryina | 11.6 | 1.5 | - | - | - |
| Cladia aggregata | 24.8 | 6.4 | x | x | - |
| Cladonia ochrochlora | 19.6 | 1.5 | x | x | - |
| Coccotrema cucurbitula | 13.4 | 15.5 | x | x | x |
| Collema laeve | 0.6 | 8.8 | - | - | - |
| C. subconveniens | - | 8.5 | x | rare | - |
| Degelia durietzii | 0.2 | - | - | - | - |
| Dictyonema sericeum | 1.0 | 5.3 | rare | x | - |
| GRAPHIDACEAE species | 14.9 | 5.6 | x | x | - |
| Heterodermia microphylla | - | 3.5 | - | - | - |
| Hypogymnia turgidula | 1.5 | - | - | - | - |
| Lecidea ceroplasta | 5.0 | 11.1 | - | x | - |
| L. laeta | 3.1 | - | - | - | - |
| Leioderma amphibolum | 2.9 | - | x | x | rare |
| L. pycnophorum | - | 0.6 | - | - | - |
| Lepraria incana | 27.3 | 26.3 | x | x | rare |
| Leptogium victorianum | 0.2 | 0.6 | rare | - | - |
| Lopadium disciforme | 0.2 | - | - | - | - |
| Menegazzia inactiva | 2.9 | 1.8 | - | rare | - |
| M. minuta | - | 2.1 | - | - | - |
| M. nothofagi | 7.6 | 15.2 | rare | x | - |
| M. platytrema | 4.8 | 2.1 | - | rare | - |
| M. retipora | 15.9 | 5.6 | - | x | - |
| M. subpertusa | 0.2 | - | - | - | - |
| M. ultralucens | 1.5 | 1.5 | - | rare | - |
| M. weindorferi | 8.7 | 2.3 | - | - | - |
| Micarea prasina aggr. | 23.1 | 4.4 | rare | x | - |
| Mycoblastus sp. 1 | 0.6 | - | - | - | - |
| Nephroma australe | 3.3 | 2.3 | - | x | - |
| Ochrolechia sp. | 0.2 | - | - | - | - |
| Pannoparmelia angustata | 2.3 | - | - | - | - |
| Parmelia cunninghamii | 7.9 | 0.6 | - | x | - |
| P. pruinata | 2.9 | 0.6 | - | rare | - |
| P. revoluta | 1.9 | 0.3 | - | rare | - |
| P. sinuosa | 4.1 | 1.5 | - | rare | - |
| P. subglabra | 1.7 | - | - | - | - |
| P. tenuirima | 1.2 | - | - | - | - |
| Parmeliella nigrocincta | 1.0 | 1.5 | x | rare | - |
| Peltigera dolichorhiza | - | 0.3 | - | - | - |
| Pertusaria nothofagi | 27.9 | 7.9 | - | x | - |
| Physma sp. | - | 1.2 | - | - | - |
| Pilophorus conglomeratus | 2.5 | 0.3 | - | - | - |
| Pseudocyphellaria ardesiaca | 0.2 | - | - | - | - |
| P. argyracea | 0.6 | - | - | - | - |
| P. colensoi | 16.1 | 1.8 | x | x | - |
| P. coronata | 9.9 | 13.2 | rare | x | - |
| P. delisea | 69.4 | 73.1 | x | x | x |
| P. faveolata aggr. | 16.5 | 19.0 | x | x | - |
| P. rubella | 20.5 | 14.3 | x | x | - |
| P. subvariabilis | 13.0 | 55.3 | x | x | - |
| Psoroma durietzii | 21.1 | 5.6 | rare | x | - |
| P. euphyllum | 0.6 | 2.3 | - | x | - |
| P. leprolomum | 3.1 | 0.9 | - | rare | - |
| P. microphyllizans | 25.8 | 76.0 | x | x | x |
| P. pholidotoides | 3.1 | 17.0 | - | x | - |
| P. soccatum | 2.3 | 16.7 | rare | x | x |
| Sagenidium molle | 15.9 | 1.8 | rare | x | - |
| Schismatomma sp. | 0.8 | - | - | - | - |
| Sphaerophorus insignis | 56.8 | 30.1 | x | x | x |
| S. melanocarpus | 7.9 | 4.4 | - | x | - |
| S. ramulifer | 7.9 | 0.9 | - | x | - |
| S. tener | 43.0 | 19.3 | x | x | - |
| Sticta stipitata | 1.2 | 12.9 | x | - | x |
| Thelotrema lepadinum | 40.5 | 39.8 | x | x | x |
| Usnea arida | 19.0 | 13.2 | - | x | - |
| U. rubicunda | 0.4 | - | - | - | - |
| Species A | 25.8 | 12.3 | x | x | x |
| | | | | | |
| Total no. of species | 65 | 56 | 28 | 44 | 11 |
| Total no. of samples | 485 | 342 | 84 | 59 | 11 |

The relatively small number of lichens recorded on the minor trees can be attributed to their comparative youth and low stature and, consequently, the low diversity of available habitats for epiphytes. Observations in other forests give no reason to suppose that these trees are intrinsically incapable of supporting rich epiphytic floras. Morphologically, Phyllocladus is intermediate between Nothofagus and Eucryphia, and this is reflected in its lichen flora. Its trunk becomes rough and fissured with age, providing habitats similar to those found on Nothofagus. However, its low stature (in this forest) and dense, relatively large foliage provide canopy conditions similar to those of Eucryphia. Cenarrhenes and Atherosperma are morphologically most similar to Eucryphia although their low stature in the site precludes any meaningful comparisons. Comparisons between the zonation of lichens on the different tree species are discussed below.

### 3. Distribution of lichen species with respect to height

Increasing trunk height has two major effects: a change in climate towards drier, better lit conditions and a change in substrate towards younger wood. In this section, trunk and twig data are considered individually in order to separate these effects. Lateral branch samples are omitted because of their intermediate nature. Tree species are also considered separately to examine any host-related differences which may be apparent.

The frequency (i.e. no. of occurrences/ total number of samples at a particular height) of the 44 most common lichens on trunks and twigs of Nothofagus and Eucryphia was plotted against height (see Figure 3). Trunk and twig data are represented as histograms and line plots respectively and species which are rare or absent on either host are indicated. Numbers in parentheses (1-44) in the discussion below refer to the sequence of species in Figure 3. Lichens are provisionally divided into four broadly-overlapping groups, viz. basal species, middle and upper trunk species, low level and subcanopy twig species, and canopy species. Phyllocladus, Cenarrhenes and Atherosperma have been excluded from this analysis due to insufficient samples.

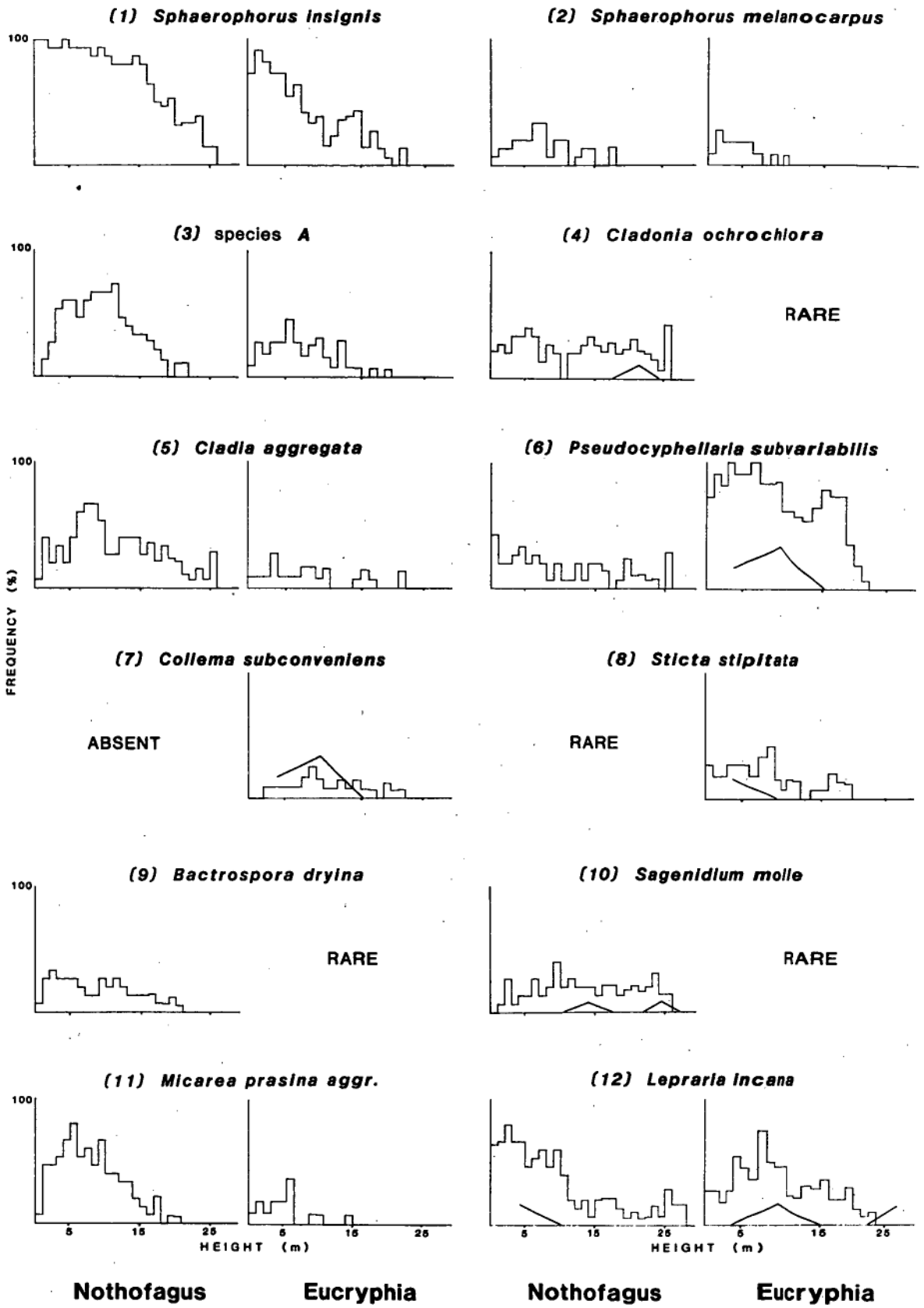



Figure 3. Frequency of lichen species with respect to height on TRUNKS (histogram plots) and TWIGS (line plots) of Nothofagus cunninghamii and Eucryphia lucida. Species which are ABSENT or RARE on either host are indicated. Tree heights are given on the lowest graphs.

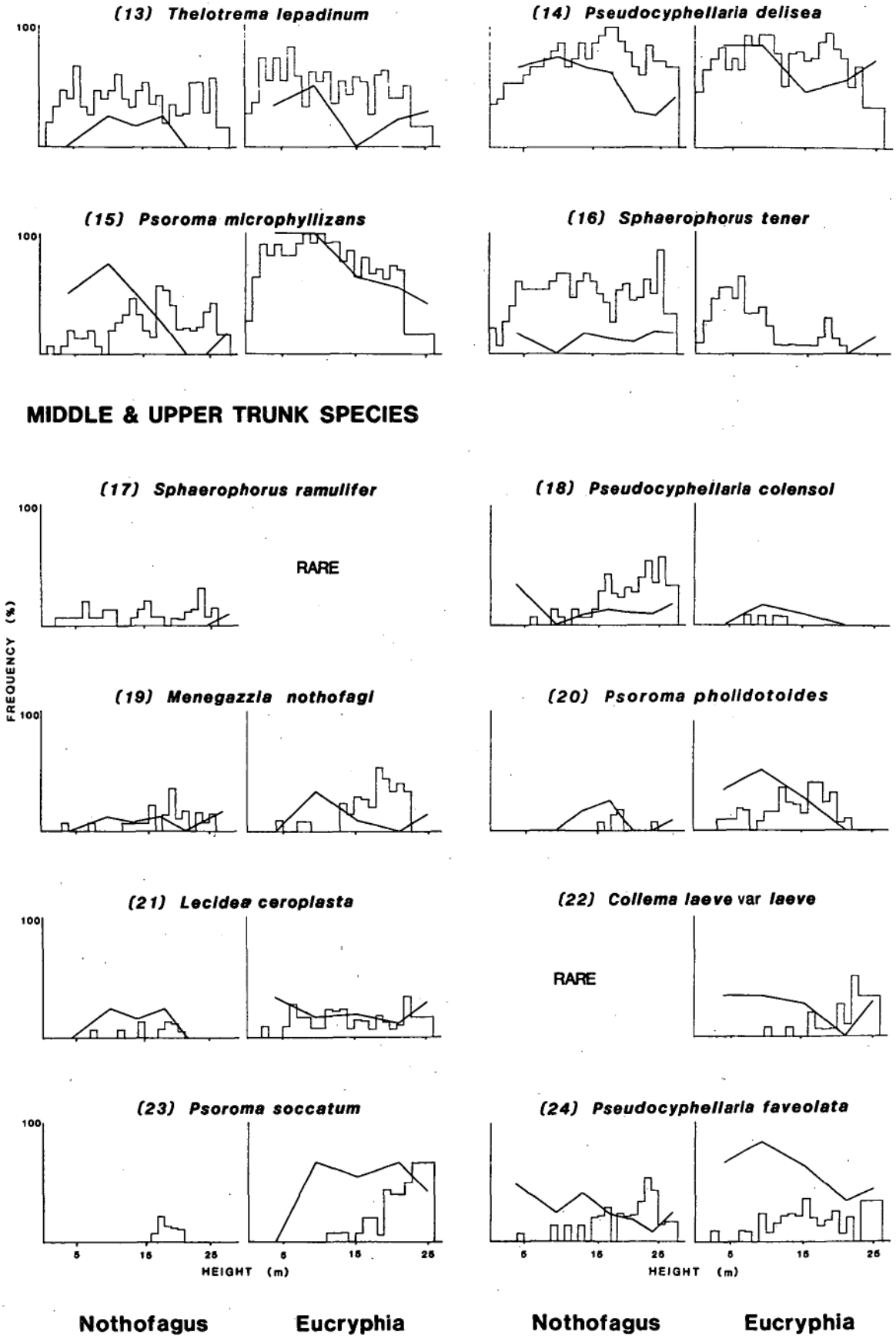



Figure 3. (continued).

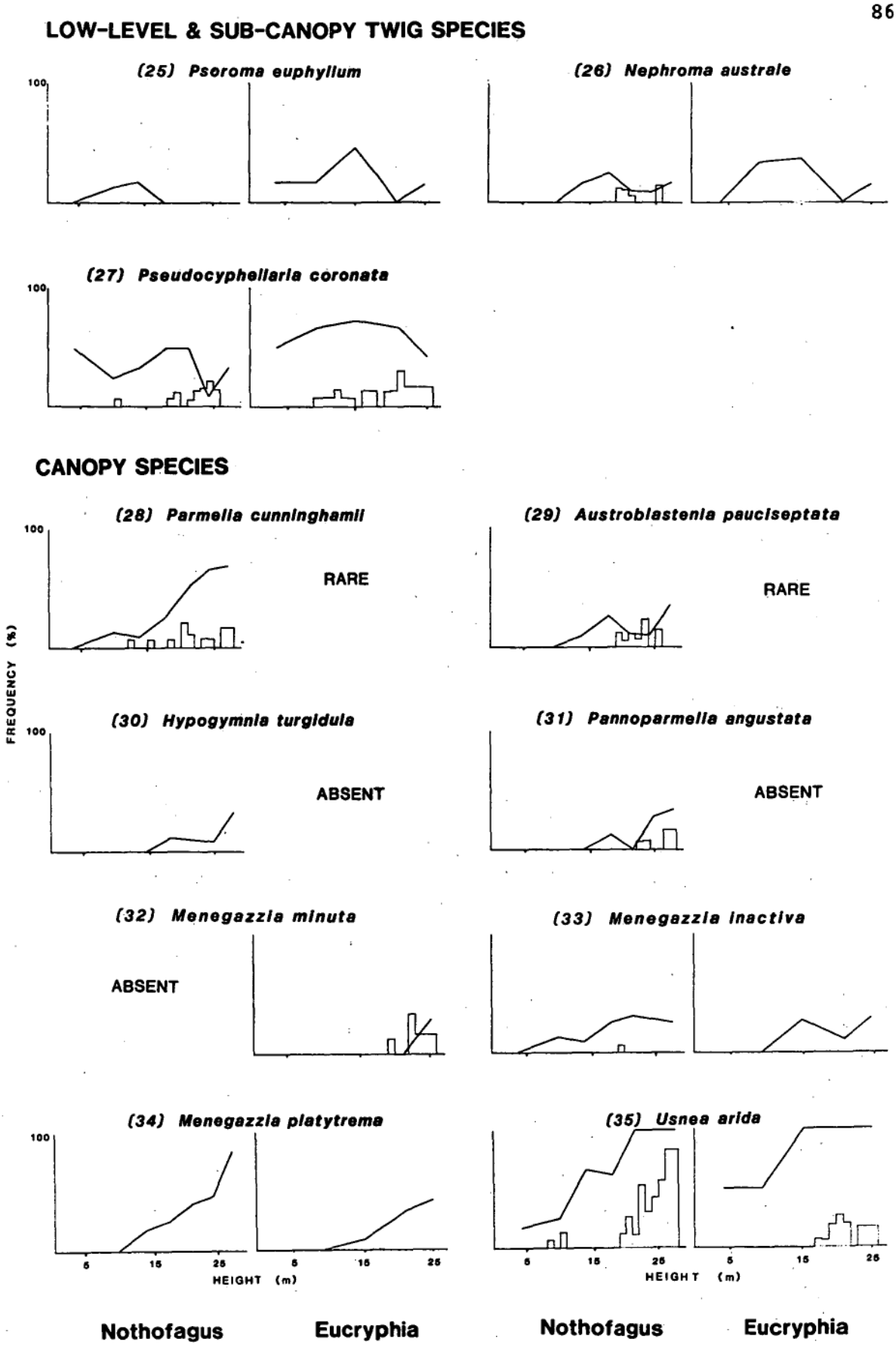



Figure 3. (continued).

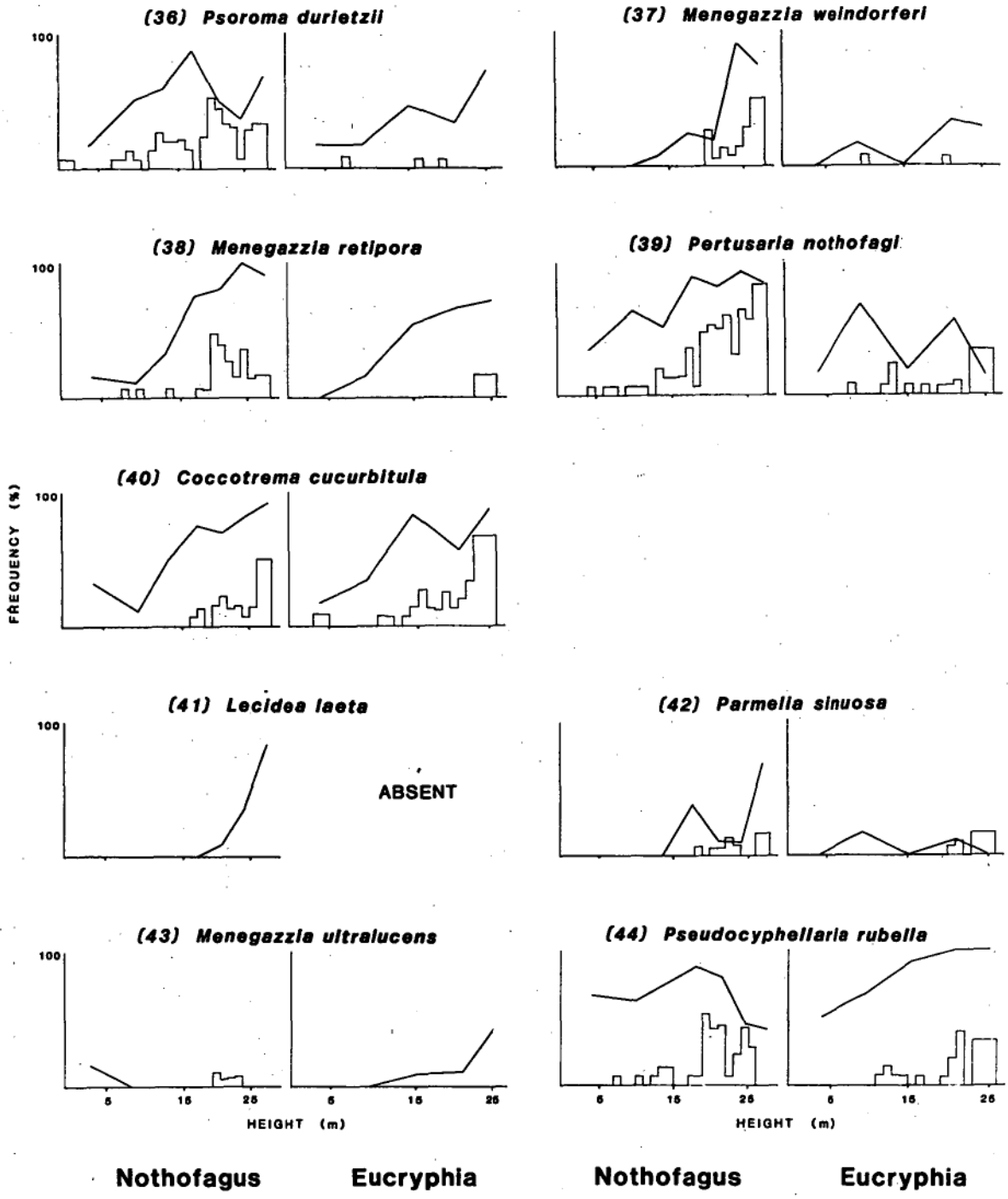



Figure 3. (continued).

(a) Basal species

Basal species are those which are most common in the lower sections of the forest and decline in frequency with increasing height. The level at which each species "cuts out" varies. A few are not present above 15 m whereas some extend up to 25 m. Other species have very broad distributions and occur virtually across the entire height of the forest. These are also classed as "basal" because of their key role in the succession towards climax basal floras. Thus there is no sharply delimitable basal zone defined by the distributions of a particular suite of lichens.

Several basal species have low frequencies in the first 1-2 m of trunk. This is most noticeable on old Nothofagus which can form extensive buttresses colonised mainly by bryophytes. The effect is also partly due to the extreme shading of this region by ground ferns and low undershrubs. Basal lichens also apparently favour trunks and few of the species studied seem adapted to basal twigs.

A number of the more successful basal lichens are either fruticose or leprose. The fruticose habit is regarded as being well-adapted to the rapid removal from the thallus of excess water which inhibits photosynthesis (Kappen 1973). Hence the fruticose growth form would be advantageous in the moist-humid environment of the rainforest interior. Leprose lichens, on the other hand, tend to resist wetting altogether. Perhaps equally important is the ability conferred by the fruticose and leprose habits to scramble over bryophytes or to form tufts which project above them. This would be a great advantage in basal habitats where bryophytes are usually the dominant plants. In contrast, most foliose and crustose lichens tend to occupy space exclusively and so tend to be more successful where bryophytes are less aggressive (see also p.181). Only five (31%) of the 16 basal species treated in Figure 3 contain cyanobacteria, either as their main photobiont or in cephalodia. This contrasts with tropical rainforests (Kappen 1973) and New Zealand cool temperate rainforests (Mark et al. 1964) where cyanobacteria are common in lichens from shaded habitats.

Sphaerophorus insignis (1) is the most common and prolific basal species in the study area, occurring on all phorophytes. It is particularly well-developed amongst the dense bryophyte mats which dominate the moist, fissured bark of mature Nothofagus. Associated

species include S. melanocarpus (2), the leprose lichen species A (3), Cladonia ochrochlora (4) and Cladia aggregata (5). Species of dry habitats, i.e. Bactrospora dryina (9), Sagenidium molle (10), Micarea prasina (11) and Lepraria incana (12), also have basal distributions, mainly because their habitat is best developed on the oldest parts of the trunks. Moreover, at higher levels, the generally more exposed conditions tend to blur any aspect differentiation which may be present below. However, Lepraria and to a lesser extent Sagenidium may also occur on the undersides of canopy branches and twigs. All these basal species are less frequent on Eucryphia which is less mossy than Nothofagus and lacks fissured bark or pronounced wet and dry aspects. Basal species preferential to Eucryphia include Pseudocyphellaria subvariabilis (6), Collema subconveniens (7) and Sticta stipitata (8). These species are foliose and their success on Eucryphia reflects the less aggressive bryophyte flora which occurs on smooth bark. Several basal species extend higher on Nothofagus than on Eucryphia, partly because Nothofagus, as the taller tree, has more high-level old wood and also tends to retain its bryophytes to higher levels. Also, a basal-like microclimate is frequently maintained high up on Nothofagus by the fern Microsorium diversifolium which causes local shading and whose rhizomes trap detritus which aids in the establishment of moisture-loving bryophytes. This fern is rarely found on Eucryphia.

Thelotrema lepadinum (13), Pseudocyphellaria delisea (14) and Psoroma microphyllizans (15) occur across a wide range of heights but usually decline on the exposed canopy twigs. These are the non-host-specific species of new growth (saplings, twigs and branches) in the interior of the forest as opposed to new growth in the canopy. The latter two species are eventually shed or overgrown where aging of the bark entails fissuring and decortication, i.e. on Nothofagus [see Figure 3, nos.(14)-(15)]. The peaks of occurrence of Pseudocyphellaria delisea and Psoroma microphyllizans are displaced upwards from the base of Nothofagus trunks due to the loss of these species from the lowest (oldest) parts of old trees as the bark is shed. On Eucryphia trunks, no such displacement is evident because trunks of all ages remain smooth and suitable for the continued survival of these species. Thelotrema lepadinum (13) is not displaced on Nothofagus trunks because it is able to persist on very old bark on dry aspects where decortication is slower and competition from

bryophytes or other lichens is minimal. All three species maintain broad basal distributions on twigs.

Sphaerophorus tener (16) has a very broad distribution and can occur on bare, smooth bark or amongst bryophytes on rough bark. Its prominence at low levels in the forest warrants its inclusion as a basal species.

(b) Middle and upper trunk species

The "middle and upper trunk" is a vaguely defined area ranging from c. 7 m above the ground to the axes of the crown. With respect to climate, this region is intermediate between the base of the trunk and the canopy. It extends above the stratum of tall shrubs and low trees but remains shaded by the dominant canopy above. At this level, Nothofagus wood is young but its smooth bark is beginning to fissure and peel. The overall cover of bryophytes is markedly lower than in the basal region. Nothofagus is still partly mossy, the major species being Leptostomum inclinans, but the bark of Eucryphia is almost bare. Major branching occurs in this zone, providing additional habitats. However, the evaluation of differences in the lichens between the tree species at this height is difficult and no clear-cut factors such as bark roughness or aspect differences appear to be involved.

The region is one of potentially high diversity because it features an intermingling of two disjunct floras, that of the base and that of the canopy. Barkman (1958) noted that middle trunk regions in European forests generally have few characteristic species. In contrast, in Tasmanian rainforest, several species are more or less confined to this region. These species are often of particular interest because they are most likely to be overlooked in "ground-based" surveys. For example, most canopy species are usually well-represented in the litter on fallen twigs but middle trunk regions are available for study only where entire trees have fallen.

The most conspicuous and dominant genera at this height are Pseudocyphellaria and Psoroma, and even their basal representatives tend to attain their maximum size and lushness at this level. In contrast to the basal species, 63% of the middle trunk lichens contain cyanobacteria. The lichens of this zone are adapted to younger wood and so, unlike basal species, have significant occurrences on both twigs and trunks. This is illustrated by the

distributions of Collema laeve (22), Psoroma soccatum (23) and Pseudocyphellaria faveolata aggr.(24). At lower levels, these species occur mainly on twigs but with increasing height and decreasing substrate age, their frequencies on trunks and twigs converge. Menegazzia nothofagi (19) is a characteristic species of this zone and may occur either directly on bark or over bryophytes. Species with a preference for bare, smooth bark, e.g. Lecidea ceroplasta (21), Psoroma pholidotoides (20) and P. soccatum (23), are usually best represented on Eucryphia. Those with a preference for mossy or cracked bark, e.g. Sphaerophorus ramulifer (17) and Pseudocyphellaria colensoi (18), are more common on Nothofagus.

(c) Low level and subcanopy twig species

As discussed above, the flora of the middle and upper trunk region shows an increasing ability to occur on both trunks and twigs. In contrast, basal species are predominantly trunk species whilst canopy species (see below) are mostly twig species. Low level and subcanopy twigs constitute a specialised habitat which combines a twiggy substrate typical of the canopy with a climate more characteristic of the middle to upper trunk. Much of the flora of these twigs is analogous to that of trunks of a corresponding height, and species common in both habitats include Psoroma soccatum and Pseudocyphellaria faveolata aggr. However, some species show a distinct preference for only twigs at this level. These include Psoroma euphyllum (25), Nephroma australe (26) and Pseudocyphellaria coronata (27) which are mainly confined to the twigs of lateral branches, the canopies of low trees and the twigs of low undershrubs such as Trochocarpa cunninghamii. These species are absent from exposed high canopy twigs.

(d) Canopy species

The "canopy" consists of the uppermost leafy twigs and constitutes the upper boundary of the forest. It is exposed to extreme climatic conditions: it receives the most direct precipitation yet is most subject to drought, being better lit, warmer, windier and composed of thinner substrates which dry out more readily than the rest of the tree. The tallest trees receive uninterrupted light and usually possess well-developed canopy floras. Many other trees, including the subdominants, are shaded and consequently their crowns may have more affinities to twigs from

lower levels. However, the unevenness of the forest canopy also means that some low trees may have their crowns completely exposed. Bark morphology does not provide an explanation for lichen distributions because the twigs of both phorophytes are smooth. Instead canopy characteristics such as leaf size and branching pattern are important because they affect the humidity within the canopy and the degree of light penetration [see p.66 and Kershaw (1964)]. Thus the fact that Nothofagus possesses small leaves and a loose, open branching pattern whilst Eucryphia has larger leaves and crowded, almost erect branches accentuates the height differences between the two trees.

The canopy is a floristically distinctive region. Large, easily dislodged species of Pseudocyphellaria and Psoroma are virtually absent and the cover and diversity of bryophytes is markedly reduced. Most lichens are tightly appressed and crustose lichens are common. Thirteen (76%) of the 17 species illustrated, including the dominant canopy genera Menegazzia, Usnea and Parmelia, are bright grey or pale coloured, probably as an adaptation to reflecting high light intensities (see Kappen 1973, Kershaw 1975). This contrasts with 38% (six out of 16) grey species in the basal zone and none at all in the middle zones. On the other hand, only three of the canopy species (18%) contain cyanobacteria. The canopy flora of Nothofagus is more diverse and better developed than that of Eucryphia, presumably because of the morphological characteristics of the trees as discussed above. Most species, e.g. Parmelia cunninghammii (28), Austroblastenia pauciseptata (29), Hypogymnia turgidula (30) and Pannoparmelia angustata (31), are more common on or confined to Nothofagus and only Menegazzia minuta (32) and M. ultralucens (43) are more common on Eucryphia. Parmelia sinuosa (42) and Lecidea laeta (41) are examples of essentially non-rainforest species which can occur at the boundary of the rainforest (in this case the upper boundary). Pioneer canopy species include Pertusaria nothofagi (39) and Coccotrema cucurbitula (40). As they age, the canopy twigs are invaded by upper trunk species from below. Several canopy species, e.g. Menegazzia inactiva (33) and M. platytrema (34), are overgrown and hence these are absent on trunks. However, others are more persistent and may occur on both canopy twigs and the upper areas of the trunk, e.g. Usnea arida (35), Psoroma durietzii (36), Menegazzia weindorferi (37), M. retipora (38) and Pseudocyphellaria rubella (44). These lichens usually extend to lower levels on Nothofagus than

on Eucryphia and this situation is again due to the greater openness of the Nothofagus canopy.

4. The relationship of height to species diversity

Correlations between lichen diversity and height have been observed by Hale (1952), Hinds (1970) and others who noted that the number of species generally increases with height, although Gough (1975) did not observe this trend. Most workers have operated with cylindrical "quadrats", i.e. "slices" of trunk one or several metres high. Calculations on this basis may be affected by variable sample size (due to varying trunk diameters), a problem acknowledged by Culberson (1955) who nevertheless felt that in his studies even the smallest samples were sufficiently large.

Diversity can be assessed by several methods (see Whittaker 1975, p.94) and two are considered in this study. The first refers to the average number of species per sample at each height interval and is here designated as "species density". The second considers the total number of species recorded from all samples at each height interval and is here termed "potential diversity". The latter quantity has been used more extensively (see authors above).

Figure 4 illustrates the changes in both "species density" (solid histogram) and "potential diversity" (line histogram) on trunks and twigs of Nothofagus and Eucryphia. Potential diversity on trunks of both tree species shows a steady increase with height followed by a sharp decline in the subcanopy area, the region of trunk within the crown. Here the blanket effect of the surrounding foliage excludes most lichens except for occasional, poorly developed crustose species which were not included in the study. The peak of diversity at 18-23 m on Nothofagus and 12-17 m on Eucryphia results mainly from the mingling of basal and canopy floras at these levels as well as from a diversification of habitats, arising from the presence of main branches. The peak is more pronounced on Nothofagus, mainly because of a greater difference between the lichens of the base of the trunk and those of the canopy (due to the transition from rough to smooth bark). The trend on twigs is generally similar to that on trunks but without any sharp peaks. This could be attributed to the lack of variation in the substrate.

"Potential diversity" is effectively a measure of diversity across the forest and peaks can also be due to the fact that at

certain heights, for example 15-25 m, the samples on which the statistic is based are likely to be more variable and include both "basal" types from very tall, old trees and "high trunk" types from lower or younger trees. In contrast "species density" is a measure of the average change in diversity on a single tree and is not confounded by such anomalies in the forest. Figure 4 shows that "species density" is relatively constant on both phorophytes, fluctuating around 6 species/sample on trunks and 10 species/sample on twigs. The data suggest that the impression of an increasing abundance of lichens with increasing height on a tree results mainly from an increase in the cover of a few species rather than from a multiplication of species numbers.

5. The effects of substrate age

In general, the species richness of lichens could be expected to increase with substrate age. Firstly, the older the bark surface, the longer its exposure to any potentially colonising epiphytes. Also, as a trunk grows, a greater surface area becomes available for colonisation. For example, Ashton and McRae (1970) found that the diversity and profuseness of epiphytes on Nothofagus cunninghamii in Victoria increased with trunk size. Furthermore, aging may also entail a diversification of habitats such as changes in bark morphology or the development of aspect differences (e.g. as in Nothofagus), and these changes usually result in a diversification of epiphytes.

In the present study, the ages of the trees were not calculated. Discs were cut from all trees but ring counts were usually impossible due to decay of the wood. However, trunk girth was assumed to be a fair index of age. The number of lichen species present up to the 7 m level was calculated for each of the 15 Nothofagus trunks studied. This height range was selected because it lies well within the "basal" region. Above this height, other factors such as variable tree height, degree of branching or the position of the tree in the forest could also influence the lichen flora. The other tree species were omitted due to the low range of girths they represented.

The changes in species richness with respect to diameter (or age) on Nothofagus are illustrated in Figure 5. The initial increase can be interpreted mainly as a result of a diversification of

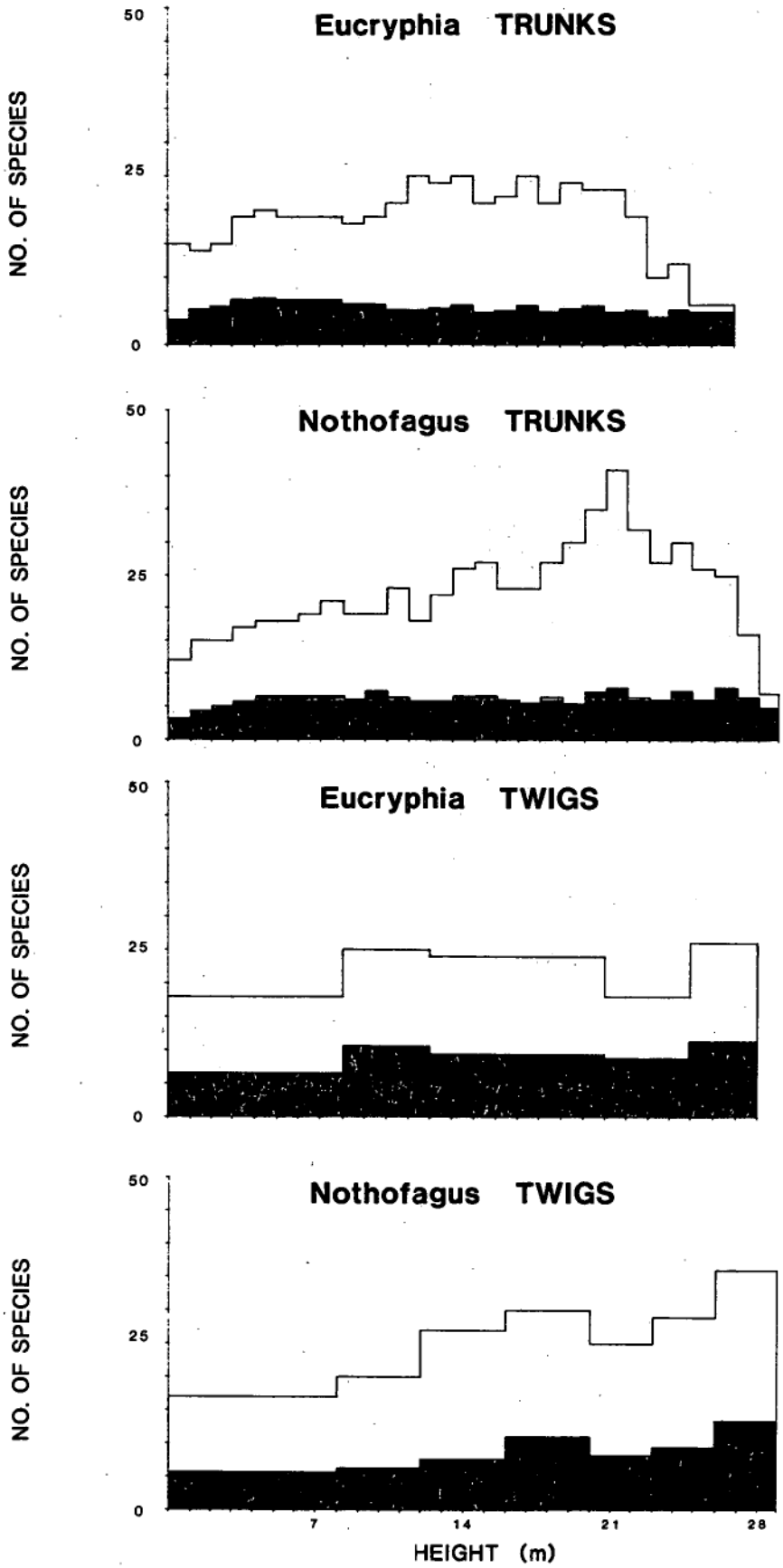



Figure 4. The relationship of height to SPECIES DENSITY (solid histogram) and POTENTIAL DIVERSITY (line histogram) on trunks and twigs of Nothofagus cunninghamii and Eucryphia lucida.

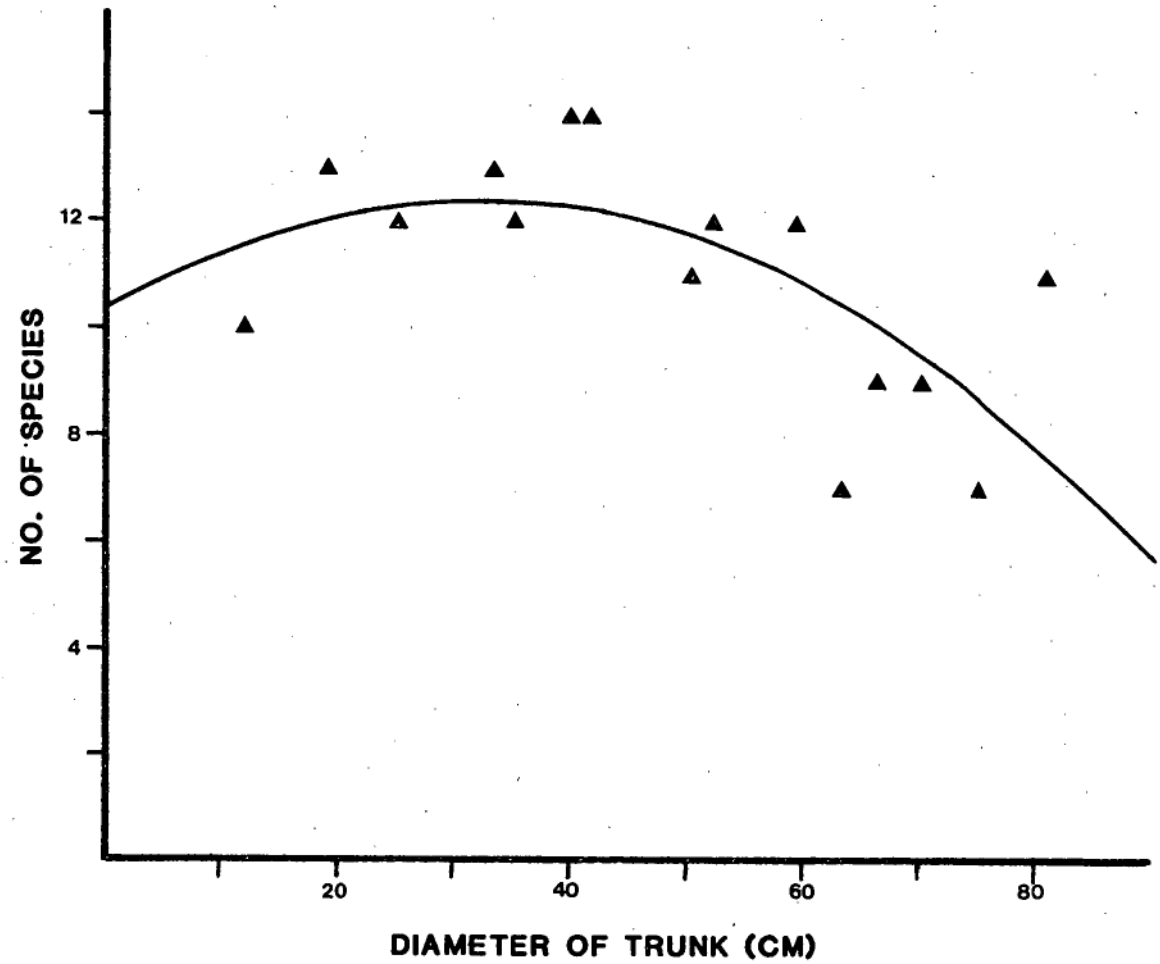



Figure 5. The relationship between species richness and trunk diameter in the lowest 7 m of Nothofagus cunninghamii trunks. The curve was fitted using a parabolic regression.

habitats as the bark fissures and aspect differences are developed. Thus there is a co-occurrence of lichens from several different niches. On very old trees, aspect differences are most marked but there is no longer the mixture of smooth and rough bark floras. Moreover, decortication is often so extensive that even some old trunk species are unable to maintain themselves and are excluded by the increased cover of bryophytes. Thus there is an overall decrease in lichen diversity. Similar trends are described for Quercus by Adams and Risser (1971) who also explained the decline in diversity by increased decortication. Thus contrary to initial expectations, species richness declines with age after an early peak which is correlated with the intermixing of pioneer smooth-bark and climax rough bark floras. These results appear to contradict those of Ashton and McRae (1970) but these authors incorporated bryophytes in their calculations and record only three lichens from the oldest trunks.

## 6. Indirect gradient analysis: ordination

Direct gradient analysis [parts 3-4 above] indicated that the epiphytic lichen flora varies in response to height. It also suggested that substrate-type is a source of variation because in many cases, the height response of a species depends on whether it occurs on trunks or twigs. Although the general trends on both Nothofagus and Eucryphia are similar, the nature of the host tree sometimes modifies the effects of height and provides a further source of variability in the lichen flora.

The aims of the indirect gradient analysis were

(a) to confirm that the changes in species composition observed in the data could indeed be related to the environmental factors of "height", "substrate type" and "host species", and

(b) to check that no additional, possibly more important, environmental gradients were involved. The presence of these would be indicated in the ordination by the extraction of unanticipated compositional trends in the data.

The method used was Detrended Correspondence Analysis (see Appendix 2).

Results of the species ordination are illustrated in Figure 6 which shows the positions of the major lichen species on the first

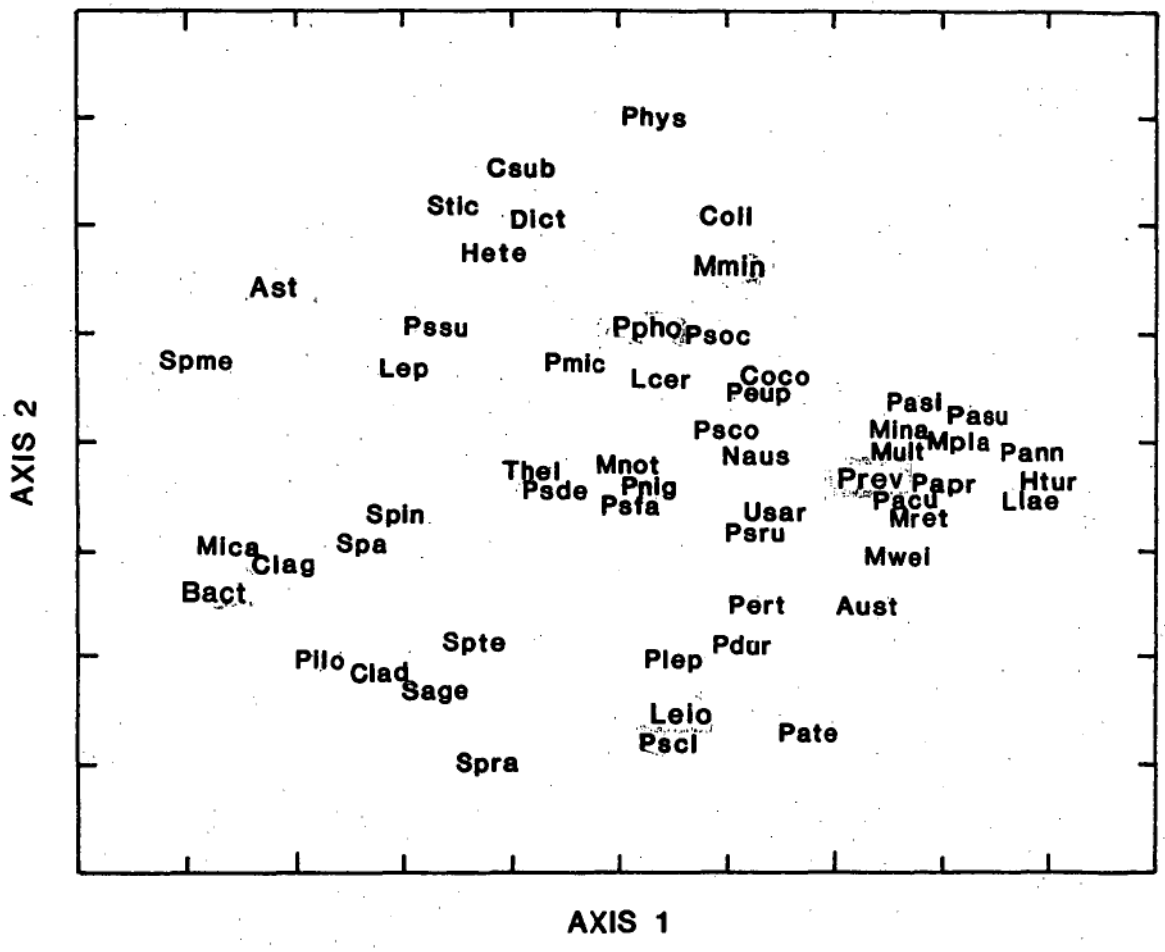


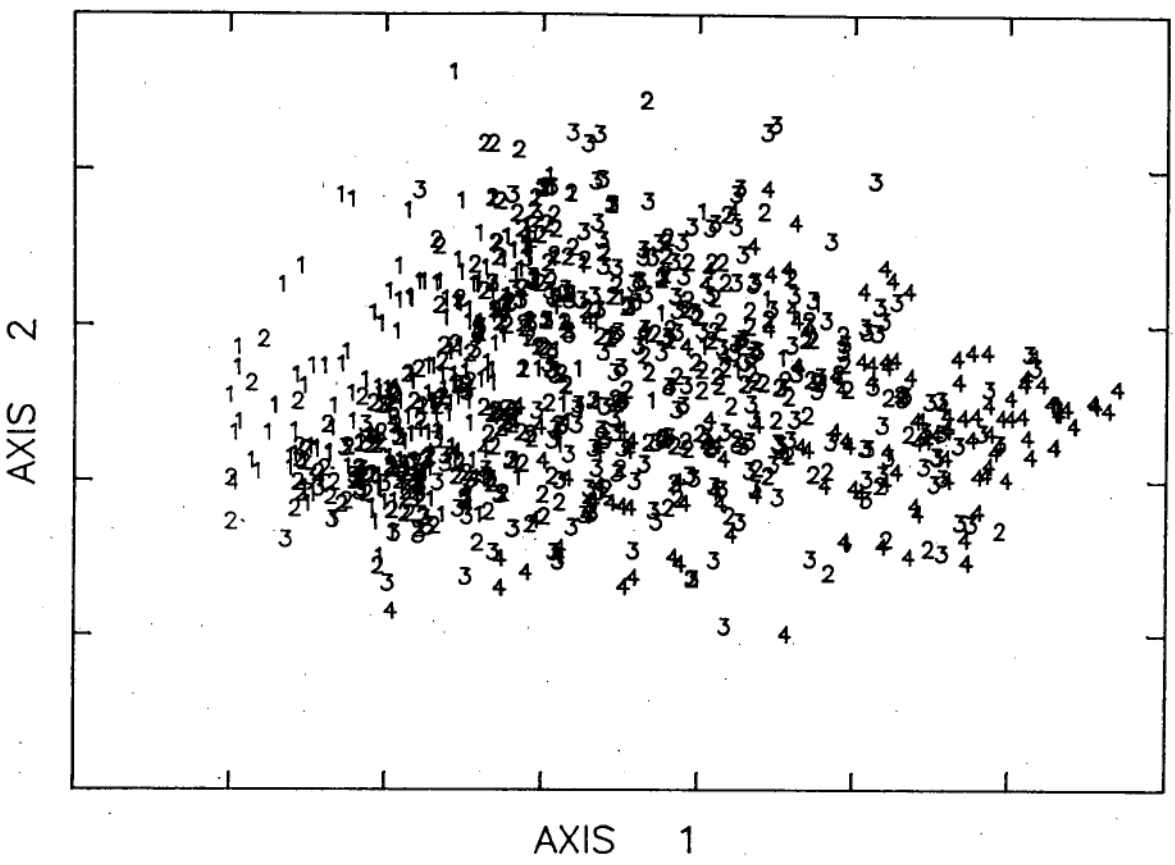

Figure 6. Location of selected lichen species on the first two axes of the DCA species ordination.

**LEGEND**: Ast- "Asteristion" Aust- Austroblastenia Bact- Bactrospora Clad- Cladonia Clag- Cladia Coco- Coccotrema Coll- Collema laeve Csub- C. subconveniens Dict- Dictyonema Hete- Heterodermia Htur- Hypogymnia turgidula Lcer- Lecidea ceroplasta Leio- Leioderma amphibolum Lepi- Lepraria Llae- Lecidea laeta Mica- Micarea Mina- Menegazzia inactiva Mmin- M. minuta Mnot- M. nothofagi Mpla- M. platytrema Mret- M. retipora Mult- M. ultralucens Mwei- M. weindorferi Naus- Nephroma australe Pacu- Parmelia cunninghamii Pann- Pannoparmelia Papr- Parmelia pruinata Pasi- P. sinuosa Pasu- P. subglabra Pate- P. tenuirima Pdur- Psoroma durietzii Pert- Pertusaria Peup- Psoroma euphyllum Phys- Physma Pilo- Pilophorus Plep- Psoroma leprolomum Pmic- P. microphyllizans Pnig- Parmeliella nigrocincta Ppho- Psoroma pholidotoides Prev- Parmelia revoluta Pscl- Pseudocyphellaria colensoi Psco- P. coronata Psde- P. delisea Psfa- P. faveolata Psoc- Psoroma soccatum Psru- Pseudocyphellaria rubella Pssu- P. subvariabilis Sage- Sagenidium Spa- species A Spin- Sphaerophorus insignis Spme- S. melanocarpus Spra- S. ramulifer Spte- S. tener Stic- Sticta Thel- Thelotrema Usar- Usnea arida

two axes of the ordination. The least common species have been removed from the diagram to prevent overcrowding. The first axis appears to represent that part of the variation related to height. Lichens which had been previously classified as basal species, e.g. Sphaerophorus insignis, S. melanocarpus, Cladia aggregata, Micarea prasina and Pseudocyphellaria subvariabilis, are located towards the left hand side of the diagram. "Canopy" species, e.g. Hypogymnia turgidula, Lecidea laeta and the species of Menegazzia and Parmelia, tend to lie to the right hand side. Species occurring in the centre of the diagram are either those from the "middle and upper trunk" category, e.g. Menegazzia nothofagi, Lecidea ceroplasta and Pseudocyphellaria faveolata aggr., or species with very broad distributions, e.g. P. delisea and Thelotrema lepadinum. The median location along the axis of this latter group represents an average of their broad height range [see Fig. 3, nos. (13)-(14)]. Rarer species whose distributions were not plotted in the direct gradient analysis occupy positions on the ordination which are in accord with their height as noted in the field. For example, from field observations, Pilophorus conglomeratus is clearly a basal species, Psoroma leprolomum is a middle region species and Parmelia revoluta is a canopy species.

The second axis of the ordination appears to represent the floristic differences between the host trees. In Figure 6, species which were preferential to Eucryphia (see Table 7), e.g. Physma sp., Collema subconveniens and Heterodermia microphylla, occur near the top of the diagram. Lichens preferential to Nothofagus, e.g. Psoroma durietzii, Pseudocyphellaria colensoi and Sphaerophorus ramulifer, occur near the bottom whilst non-preferential species are central.

Confirmation of this interpretation of the two axes is provided by the ordination of the samples. In Figures 7-9, the scores of the environmental variables for each sample have been superimposed on the location of the samples in the ordination diagram. Figure 7 depicts the height (in four classes) of each sample. Lowermost samples (coded as 1's) are located mainly at the left of the ordination and there is a general increase in height from left to right. The distribution of "sample type" on the ordination (Fig. 8) also shows that there is a shift from trunks at the left of the ordination towards twigs at the right, with lateral branches located mainly in the centre.




**LEGEND**

1 1-7 METRES
2 8-14
3 15-21
4 22-29

Figure 7. The distribution of "HEIGHT CLASS" within the configuration of samples defined by axes 1 and 2 of the DCA ordination.

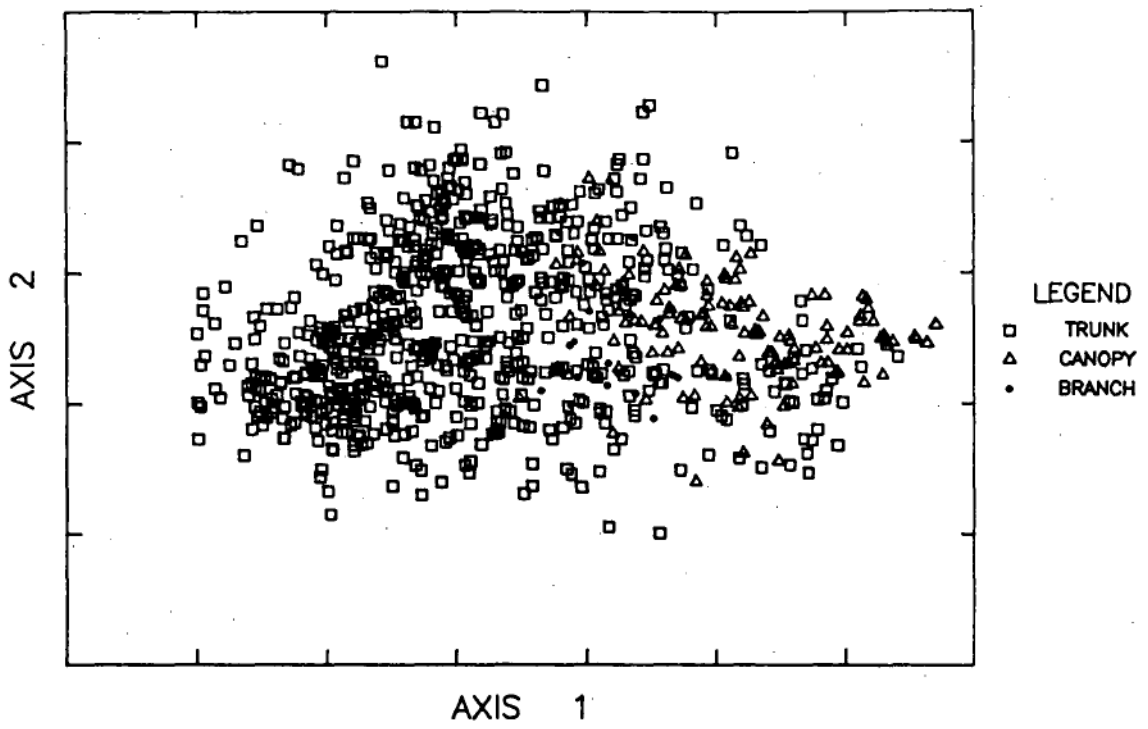



Figure 8. The distribution of "SAMPLE TYPE" within the configuration of samples defined by axes 1 and 2 of the DCA ordination.

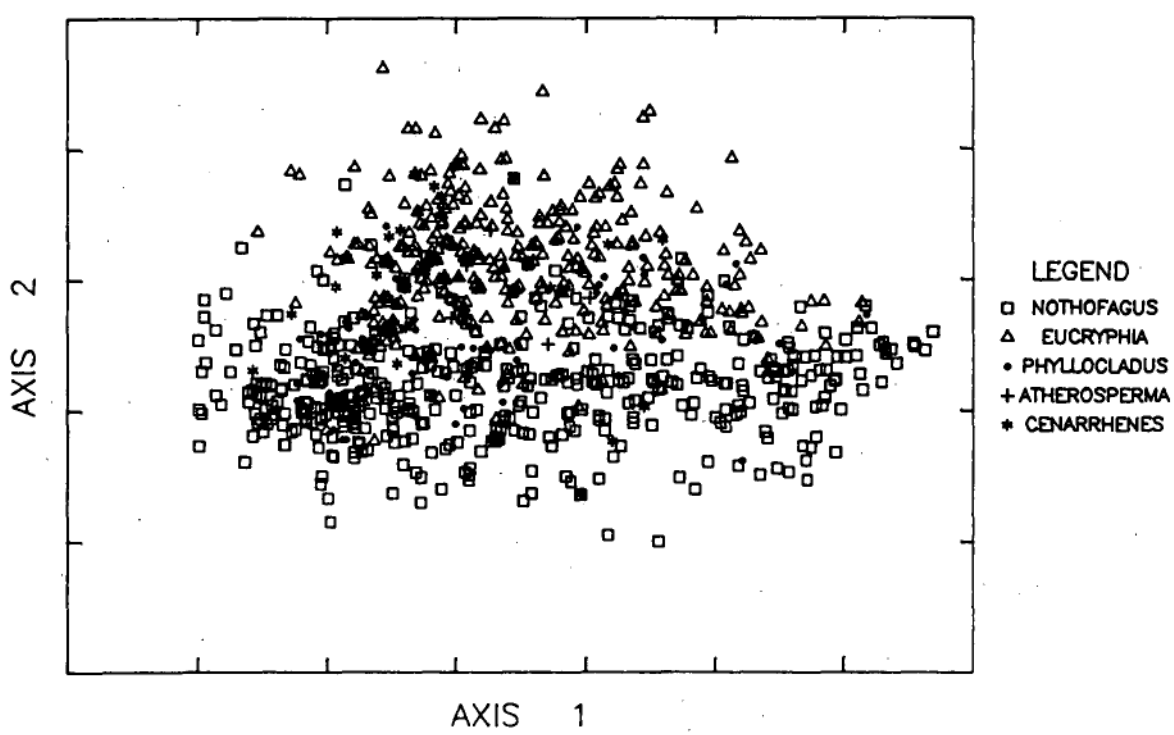



Figure 9. The distribution of "HOST TREE SPECIES" within the configuration of samples defined by axes 1 and 2 of the DCA ordination.

Figure 9 depicts "host tree species" superimposed on the sample ordination and supports the assertion that the second axis represents the floristic differences between the two trees. Samples from Nothofagus are located in the lower half of the configuration whilst those from Eucryphia are concentrated in the upper half. Phyllocladus occupies a diffuse region spanning both major tree species. Samples overlapping Nothofagus are mainly low on the height gradient (axis 1) whereas those overlapping Eucryphia have high scores on this axis. This also supports the assertion made previously that Phyllocladus has a basal flora analogous to Nothofagus (due to the rough bark on its trunk) but that its canopy flora is similar to Eucryphia (due to its dense, large foliage and low stature). Cenarrhenes and Atherosperma samples all occupy a low to middle position on axis 1 due to the low height and small diameter of these trees.

Another feature of Figure 9 is that Nothofagus extends over a wider range of the height gradient (axis 1) than does Eucryphia. The greater height, open crown and consequently better development of the canopy flora of Nothofagus would explain this effect at the upper (right hand) end of this gradient. The effect at the lower (left hand) end could appear anomalous, given that sampling on both trees began from 1 m. However, this is due to the fact that old, lowermost portions of Eucryphia retain smooth bark and are hence floristically analogous to smooth-barked, higher (and younger) portions of Nothofagus.

From the ordinations, it is apparent that changes in substrate are an important aspect of increasing height. The height gradient entailed in axis 1 is complex and consists of a climatic component (the shift from a shaded, moist climate to an arid, exposed climate) and a substrate component (a shift from old, often rough trunks to young, smooth twigs). Height above ground per se is simply a very approximate index of position on this gradient.

The three variables which were scored in the study, i.e. tree species, height and sample type, are accounted for by the first two axes of the ordination. Third and fourth axes were also extracted in the analysis but have not been presented as they could not be interpreted in terms of the variables scored, nor do they reflect any floristic trend observed in the field. They may be related to some minor variable yet to be determined or they may simply be spurious

artefacts generated by the ordination method (cf. Minchin 1983, p.322).

## 7. Classification

The results of the indirect gradient analysis illustrate the continuous nature of the data. Nevertheless, for the purposes of summary and description, it is convenient to dissect this continuum into several classes. In the direct gradient analysis, lichens were classified into 4 groups, viz. basal, middle to upper trunk, low level and subcanopy twig, and canopy species. This classification was based entirely on the performance of each individual species with respect to height above the ground. In this section, a refined classification is derived based on the co-occurrence of species. The new classification also takes into account the results of the ordinations which showed that height is but a single component of the complex gradient which exists between the forest floor and the canopy. Other factors involved include the age and twigginess of the substrate. Moreover, the interaction of these factors is modified by the nature of the host tree.

The technique adopted for the classification was Two-way Indicator Species Analysis using the computer program TWINSPAN (Hill 1979b) (see Appendix 2). Ten groups were derived and the species composition of each group is given in Table 8. The spatial distribution of the groups in the forest is illustrated in Figure 11(a)-(f) which shows the general layout of the forest and the position of each tree sampled. The relationship of each group with height and host species is evident in this diagram. The forest has been divided into strips running North-South. Parts (a)-(f) are adjacent strips from East to West and reference points are provided for their alignment. Trees are represented to scale, with sampled individuals numbered according to Table 4 and unsampled trees shown as "stumps".

The classes resulting from the new classification represent groups of species with similar distributions with respect to height, substrate type and host species. They are not necessarily phytosociological units because the collection of data did not preserve the homogeneity of each sample. For example, aspect differences were ignored although it is known that these frequently correspond to marked floristic differences. Nevertheless, in most

Table 8. Percentage frequencies of lichens in each of the 10 groups derived by TWINSPAN (important values shown in bold type).

| | 1 | 2 | 3 | 4 | 6 | 5 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Pseudocyphellaria delisea | **51** | **100** | **87** | **79** | **84** | **97** | **91** | **72** | **60** | 6 |
| Thelotrema lepadinum | 17 | **86** | **42** | **48** | **54** | **70** | **35** | **26** | 6 | - |
| Psoroma microphyllizans | 2 | 7 | **47** | **82** | **93** | **59** | **72** | **75** | 15 | - |
| Sphaerophorus tener | **55** | **82** | **70** | 13 | 20 | **44** | **26** | 1 | 15 | - |
| S. insignis | **99** | **88** | **98** | **52** | 10 | **22** | 2 | 1 | - | - |
| Asteristion lamelliferum | 2 | - | 2 | 3 | - | - | - | - | - | - |
| Cladia aggregata | **54** | **25** | **36** | 3 | 2 | 6 | - | - | - | - |
| Sp. A | **47** | **46** | **63** | 15 | 2 | 6 | 2 | - | - | - |
| Sphaerophorus melanocarpus | **16** | 4 | **19** | 5 | - | - | - | - | - | - |
| Micarea prasina aggr. | **61** | 11 | **30** | 2 | 1 | - | - | - | - | - |
| Cladonia ochrochlora | **44** | **19** | 7 | 2 | 2 | 13 | 2 | - | 2 | - |
| Bactrospora dryina | **25** | 14 | 7 | 2 | 1 | 2 | - | - | - | - |
| Pilophorus conglomeratus | 6 | - | - | 1 | - | 3 | - | - | - | - |
| Lepraria incana | **63** | **19** | 11 | **45** | 10 | 6 | 11 | 5 | 2 | - |
| Sagenidium molle | **31** | **35** | 3 | 1 | 5 | 6 | 2 | 1 | 3 | - |
| Sphaerophorus ramulifer | 6 | **32** | 5 | - | 6 | 5 | - | - | 2 | - |
| GRAPHIDACEAE species | 10 | **39** | 5 | 5 | 16 | 6 | **22** | 12 | 8 | 8 |
| Pseudocyphellaria subvariabilis | 8 | 19 | **58** | **89** | **30** | 5 | - | - | - | - |
| Sticta stipitata | 1 | - | 3 | **22** | 3 | - | 2 | 2 | - | - |
| Collema subconveniens | - | - | - | 13 | 5 | - | - | 2 | - | - |
| Heterodermia microphylla | - | - | - | 5 | 2 | - | - | - | - | - |
| Arthothelium sp. 1 | - | - | - | 1 | 1 | - | - | - | - | - |
| Dictyonema sericeum | - | - | 4 | 6 | 9 | - | 4 | - | - | - |
| Pseudocyphellaria faveolata aggr. | 4 | 11 | 1 | 8 | **29** | **33** | **59** | **44** | **20** | - |
| Menegazzia nothofagi | 1 | 5 | 3 | 5 | **31** | 9 | **48** | **14** | 6 | 2 |
| Psoroma pholidotoides | - | - | 2 | 8 | **25** | - | **22** | **25** | 6 | - |
| Pseudocyphellaria rubella | 1 | 2 | 2 | 1 | 2 | **13** | **65** | **58** | **91** | **31** |
| Psoroma durietzii | 1 | 7 | 8 | 1 | 1 | **23** | **39** | **21** | **63** | **45** |
| Pertusaria nothofagi | 5 | 14 | - | - | 2 | 11 | **70** | **30** | **68** | **80** |
| Usnea arida | 4 | 9 | 3 | 2 | 5 | 6 | **26** | **35** | **69** | **80** |
| Pseudocyphellaria colensoi | 2 | 16 | 1 | - | 2 | **44** | **57** | 7 | 22 | - |
| Leioderma amphibolum | - | - | 1 | 1 | - | 5 | **20** | 2 | 3 | - |
| Nephroma australe | - | - | - | - | 1 | 2 | **17** | 7 | **15** | 2 |
| Psoroma euphyllum | - | - | - | - | - | - | 7 | 7 | 6 | - |
| P. soccatum | - | - | - | 1 | 16 | 2 | 15 | **43** | 17 | 2 |
| Collema laeve | - | - | - | - | 9 | - | - | **23** | 5 | 4 |
| Lecidea ceroplasta | 1 | - | 3 | 7 | 5 | 11 | 4 | **38** | 3 | 4 |
| Menegazzia minuta | - | - | - | - | 1 | - | - | 6 | 2 | - |
| Pseudocyphellaria coronata | - | 4 | 3 | - | 11 | 8 | **37** | **53** | **43** | - |
| Coccotrema cucurbitula | - | 4 | - | 6 | 6 | 2 | 4 | **56** | **42** | **76** |
| Menegazzia retipora | - | - | - | - | - | 5 | 4 | 11 | **69** | **82** |
| M. platytrema | - | - | - | - | - | - | - | 4 | **20** | **31** |
| M. weindorferi | - | - | - | - | - | 8 | 4 | 1 | **38** | **35** |
| Parmelia cunninghammii | - | - | - | - | - | 3 | 4 | 4 | **32** | **31** |
| Menegazzia inactiva | - | - | - | - | - | - | 2 | 2 | **18** | **14** |
| Austroblastenia pauciseptata | - | - | - | - | 1 | 2 | 7 | - | **12** | **18** |
| Parmelia pruinata | - | - | - | - | 1 | - | - | 4 | 9 | **14** |
| P. revoluta | - | - | - | - | 1 | - | - | 1 | 8 | 8 |
| Menegazzia ultralucens | - | - | - | - | - | - | - | 4 | 8 | 10 |
| Parmelia tenuirima | - | - | - | - | - | - | 2 | 1 | 5 | 2 |
| Usnea rubicunda | - | - | - | - | - | - | - | - | 2 | 2 |
| Parmelia sinuosa | - | - | - | 1 | 1 | - | 2 | 2 | **12** | **27** |
| Lecidea laeta | - | - | - | - | - | - | - | - | 6 | **22** |
| Parmelia subglabra | - | - | - | - | - | - | - | 1 | 3 | **10** |
| Hypogymnia turgidula | - | - | - | - | - | - | - | - | 2 | **12** |
| Pannoparmelia angustata | - | - | - | - | - | - | - | - | 5 | **16** |
| Degelia durietzii | - | - | - | - | - | - | - | - | - | 2 |
| Ochrolechia sp. | - | - | - | - | - | - | - | - | - | 2 |
| Bacidia sp. 1 | - | - | - | 1 | 1 | - | 7 | 4 | 6 | 4 |
| Leptogium victorianum | - | - | - | - | 1 | - | 4 | 1 | - | - |
| Physma sp. | - | - | - | - | 1 | 2 | - | 2 | - | - |
| Menegazzia subpertusa | - | - | - | - | - | - | - | - | 2 | - |
| Parmeliella nigrocincta | 1 | - | - | 1 | 4 | 3 | 4 | 1 | - | 2 |
| Leioderma pycnophorum | - | - | - | - | - | - | 2 | 1 | - | - |
| Pseudocyphellaria ardesiaca | - | - | - | - | - | - | 2 | - | - | - |
| P. argyracea | - | - | 1 | - | - | - | - | - | 3 | - |
| Psoroma leprolomum | 1 | - | - | - | 1 | 9 | 2 | 6 | 6 | - |
| Schismatomma sp. | - | 2 | - | - | 2 | - | - | - | 2 | - |
| Mycoblastus sp. 1 | - | - | 3 | - | - | - | - | - | - | - |
| Lopadium disciforme | - | - | - | - | - | - | 2 | - | - | - |
| Peltigera dolichorhiza | - | - | - | 1 | - | - | - | - | - | - |

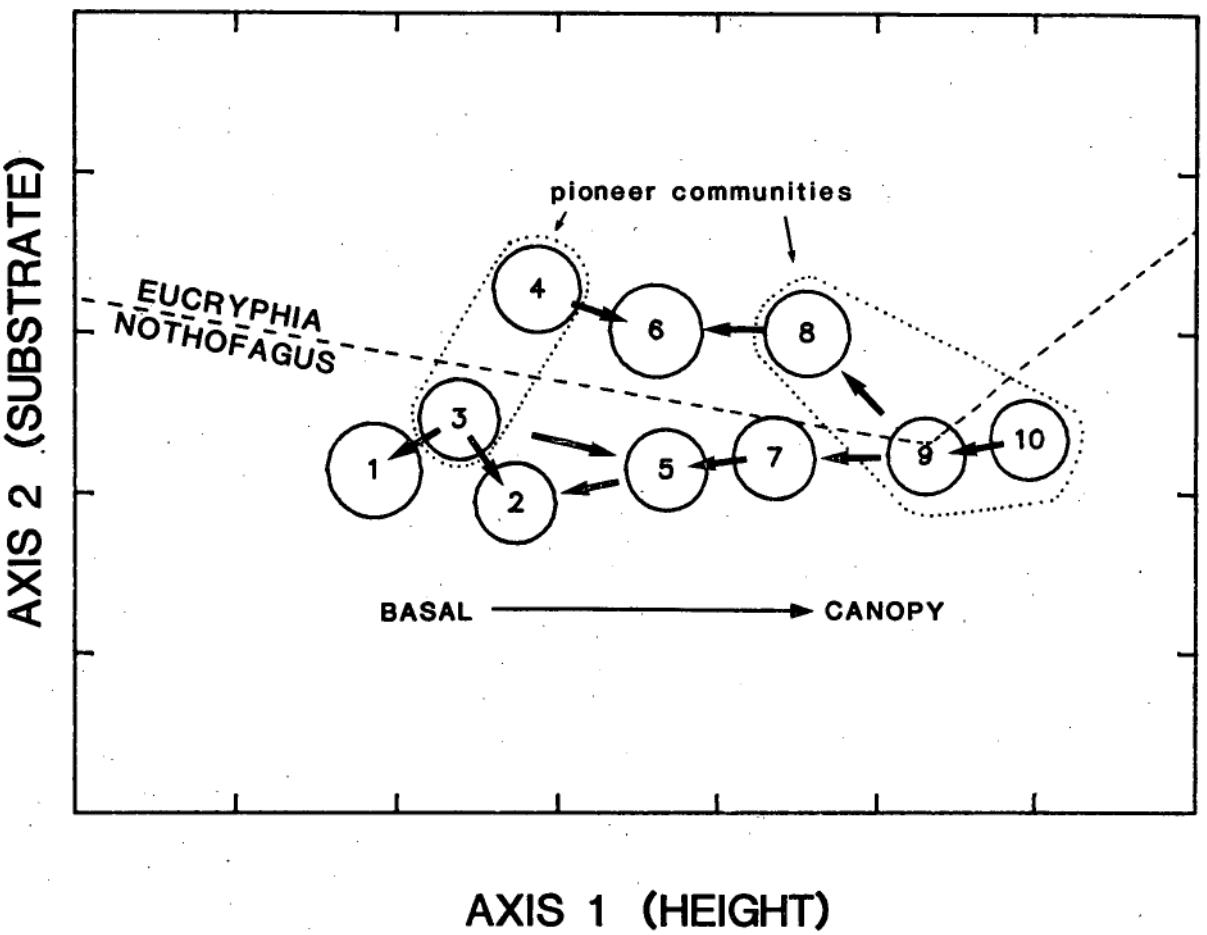



Figure 10. The disposition of 10 groups of samples derived by a TWINSPAN classification on the first two axes of the DCA ordination. The numbers are arbitrary labels marking the centroid of the co-ordinates of each group. The circle radii are equal to the Root Mean Square average of the ordination distances between individual samples and their group centroid. The groups are described in the text and in Table 8.

cases, the derived classes parallel the results of the phytosociological studies described in part IIIC (below).

Figure 10 illustrates the location of the 10 groups superimposed on the ordination of samples (taken from part 6 above). The ordination axes are now labelled according to the environmental gradients they are thought to represent. The groups are clearly related to both the "height" and "host species" gradients, and proposed routes of succession are indicated by arrows.

Production and colonisation of new habitats occurs both within the forest on young saplings and in the canopy on new twigs. Groups 8-10 represent the pioneer vegetation of canopy twigs. As these twigs age, they are overtopped by new growth and thicken, ceasing to be twigs. Thus their vegetation is effectively "pushed" down the height gradient, a succession represented by the shift from group 10 to group 2 on Nothofagus via groups 9,7 and 5, and from group 9 or 8 to group 6 on Eucryphia. Groups 3 and 4 represent pioneer vegetation within the forest on Nothofagus and Eucryphia respectively. With age, the lichen flora of the lowest portions of Eucryphia will remain of the group 4 type whilst the middle portions will tend towards a group 6 flora. On Nothofagus, the succession is more complex due to the changes in bark morphology and the development of aspect differentiation which accompany aging. The pioneer flora (group 3) can develop into either of groups 1,2 or 5, depending on the height of the trunk region involved, its degree of fissuring and whether there is any differentiation into wet and dry aspects. Thus from a pioneer flora with a broad distribution with respect to height, 3 groups with narrower height distributions are developed.

Each of the groups is briefly discussed below. Their order of treatment is according to their relationships in the forest.

(a) Group 1

This group constitutes the dominant and climax basal vegetation of mature Nothofagus trunks and ranges up to c. 25 m on the oldest, tallest trees. It represents a mixture of two discrete communities: a Sphaerophorus insignis - dominated community of moist mossy aspects and a Sagenidium molle community of dry aspects. Other characteristic old trunk species present include Micarea prasina aggr., Bactrospora dryina, Lepraria incana and Pilophorus conglomeratus. Pioneer species, e.g. Pseudocyphellaria subvariabilis, P. delisea, Thelotrema

lepadinum and Psoroma microphyllizans, are relatively poorly represented having been eliminated by decortication or competition with bryophytes. Detailed descriptions of these two communities are given on pp.127-139.

(b) Group 2

Group 2 generally occurs where the wood is younger, the trunks less fissured and aspect differentiation less acute. It is most common on Nothofagus, usually above group 1, but is also occasional near the bases of the other trees. It represents an early developmental stage of group 1 and has many species in common with it, e.g. Sagenidium molle, Cladia aggregata, Sphaerophorus insignis, usually present as small thalli. Some pioneer species, e.g. Pseudocyphellaria delisea and Thelotrema lepadinum, attain their maximum development in this group because decortication or competition with bryophytes is not yet severe. Sphaerophorus ramulifer and Graphis insidiosa are characteristic species of the group. The group shows affinities to the Sphaerophorus ramulifer-S. tener community described on p.139.

(c) Group 3

This group is the Nothofagus - preferential facies of the Pseudocyphellaria subvariabilis - Psoroma microphyllizans pioneer community which occurs on smooth bark in shaded habitats (see p.143). Other important species include Pseudocyphellaria delisea and Thelotrema lepadinum. With age, this community develops towards group 1 or group 2 floras as the bark fissures and aspect differences become apparent. Many of the characteristic species of these groups, e.g. Sphaerophorus spp. and Cladia aggregata, are therefore already present in juvenile forms.

(d) Group 4

This group is the Eucryphia - preferential facies of the preceding community (Group 3) and constitutes the dominant basal vegetation of Eucryphia trunks. It differs from group 3 by the presence of such species as Sticta stipitata, Collema subconveniens and Heterodermia microphylla which replace the Nothofagus - preferential species, e.g. Sphaerophorus insignis and Cladia aggregata. The group tends to occur in deeper shade than its

Nothofagus analogue, often within dense leafy coppices on Eucryphia trunks.

(e) Group 6

Group 6 occurs mainly on the upper trunk, subcanopy and some low twigs and branches of Eucryphia and displaces group 4 with increased height. This region is often deeply shaded by the surrounding foliage. Bryophytes are relatively scarce. Pseudocyphellaria subvariabilis and Psoroma microphyllizans are dominant but many basal species, e.g. Sticta stipitata and Collema subconveniens, are virtually absent. These species are replaced by middle and upper trunk species such as Pseudocyphellaria faveolata aggr., Menegazzia nothofagi and Psoroma pholidotoides. Several juvenile canopy species are also present.

(f) Group 10

This group represents the pioneer vegetation of the highest twigs of the tallest trees and is found mainly on Nothofagus. The dominant lichens are mostly white or grey and include Pertusaria nothofagi, Menegazzia retipora, M. weindorferi, Coccotrema cucurbitula and Parmelia cunninghamii. Many crustose species (not recorded in this study) are also present.

(g) Group 9

Group 9 occurs on canopy twigs which are usually less exposed than those of group 10, such as high lateral branches, the crowns of the shorter trees and the small diameter axes of the high canopies. These regions include areas of new growth under more sheltered conditions as well as the next stage in succession from group 10 habitats. Diversity is very high in this group. Pertusaria nothofagi, Coccotrema cucurbitula, Usnea arida and species of Menegazzia are dominant. As well as these canopy lichens, juvenile thalli of species from lower down in the forest, e.g. species of Pseudocyphellaria and Psoroma, may also be present.

(h) Group 8

This group is found mainly on the twigs, small diameter crown axes and lateral branches of Eucryphia and Phyllocladus. These habitats are sheltered by tall Nothofagus canopies above, as well as being more protected by the larger foliage of their host trees.

Species from exposed habitats (groups 9 and 10) are poorly represented. The dominant lichens of this group include Pseudocyphellaria rubella, P. faveolata aggr. and P. coronata. Pertusaria nothofagi and Coccotrema cucurbitula are the major crustose species but may be readily overgrown by the more aggressive macrolichens. Other lichens characteristic of this group are Psoroma soccatum, Lecidea ceroplasta and Collema laeve.

(i) Group 7

Group 7 occurs mainly on the large branches and crown axes of Nothofagus or on low-level twigs of other hosts. It is derived from group 9 as the canopy twigs grow longer and thicker and become shaded by new foliage above. Lichens from very open habitats, e.g. species of Menegazzia and Parmelia, are gradually replaced by more shade-tolerant middle trunk species although Usnea arida and Psoroma durietzii tend to be more persistent. Dominant species of the group include Pseudocyphellaria colensoi, P. rubella, P. faveolata aggr. and P. coronata. P. delisea increases in cover with increasing shade. This group has many affinities with Groups 6 and 8 which occupy analogous habitats on Eucryphia. Species shared between these groups include Psoroma pholidotoides and Menegazzia nothofagi. Low level twigs ascribed to group 7 are characterised by Nephroma australe and Psoroma euphyllum.

(j) Group 5

This group is derived either from group 7 by increased shade and age of the substrate or, alternatively, from group 3 pioneer vegetation by aging under relatively exposed conditions. Like group 7, group 5 occurs in the intermediate region between the lower trunk and the crown. It is distinguished not by any characteristic species but by the blending of canopy and basal floras. Common lichens in the group include the basal pioneer species, Pseudocyphellaria delisea, Psoroma microphyllizans and Thelotrema lepadinum, the basal species Sphaerophorus insignis and S. tener, middle trunk species such as Menegazzia nothofagi and Pseudocyphellaria colensoi as well as some canopy species, e.g. Usnea arida and Pertusaria nothofagi.

8. Salient features of the classification (refer to Figure 11)

Several features are apparent from the results of the classification and the diagramatic representation of the distribution of each class:

(a) Vertical zonation is often "compressed" rather than abbreviated on low young trees (cf. Kershaw 1964). This is because the zonation is partly due to the age of the substrate and because young trees frequently grow in light gaps. For example, tree nos. 1,2 and 28 [see Fig. 11(a), (b) and (e) respectively] are low trees in clearings (or on the edge of clearings) which possess a complete height range of lichen communities.

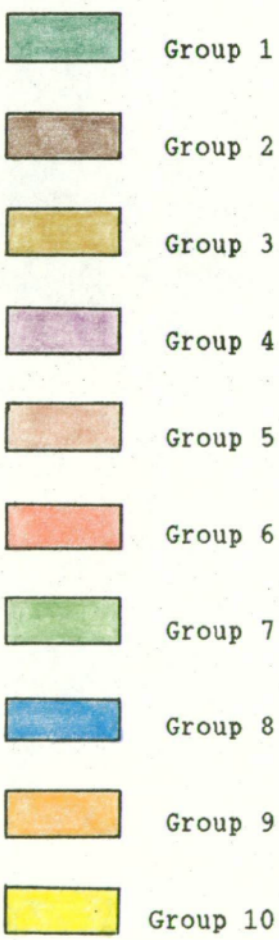
(b) The effect of substrate age is illustrated by the fact that at any given height, a twig is "floristically" higher than its subtending branch which in turn is higher than its subtending trunk.

(c) Position in the forest with respect to distance to the nearest tree is important because this affects the local climate around the tree. For example, tree no. 27 [see Fig. 11(e)] is tall but is overtopped by trees 10 and 11 which may explain its lack of a high canopy flora. Similarly, tree no 6 [see Fig. 11(c) and also 11(b)] is overtopped and lacks the range of canopy lichens evident on other trees of similar height.

(d) The morphology of the host tree has been proposed as an explanation for the host-specificity of the lichen groups. However, the proximity to a source of lichen diaspores may also be an important factor. For example, tree no. 6, a Nothofagus [see Fig. 11(c)], supports a large proportion of Eucryphia-type samples. This may be due to its proximity to a large Eucryphia which could have acted as a source of lichen propagules. Similarly, the occurrence of Nothofagus-type canopy vegetation on the Eucryphia trees nos. 17 and 30 [see Fig. 11(f)] could be due to their location in a grove of tall Nothofagus.

Figure 11. Diagramatic representation of the Sumac Road study area showing the location of the groups derived by TWINSPAN and the positions, heights, girths and approximate branching patterns of the trees. Parts (a)-(f) are consecutive east to west strips with (a) being the northernmost segment. Reference points for the alignment of the segments are provided. Trees sampled are numbered according to Table 4. Positions of unsampled trees are indicated as "stumps".

**LEGEND**: n = Nothofagus e = Eucryphia d = Tasmannia (=Drimys)
e = Cenarrhenes p = Phyllocladus




Unsampled areas of the trees and samples not included in the analysis are left blank.

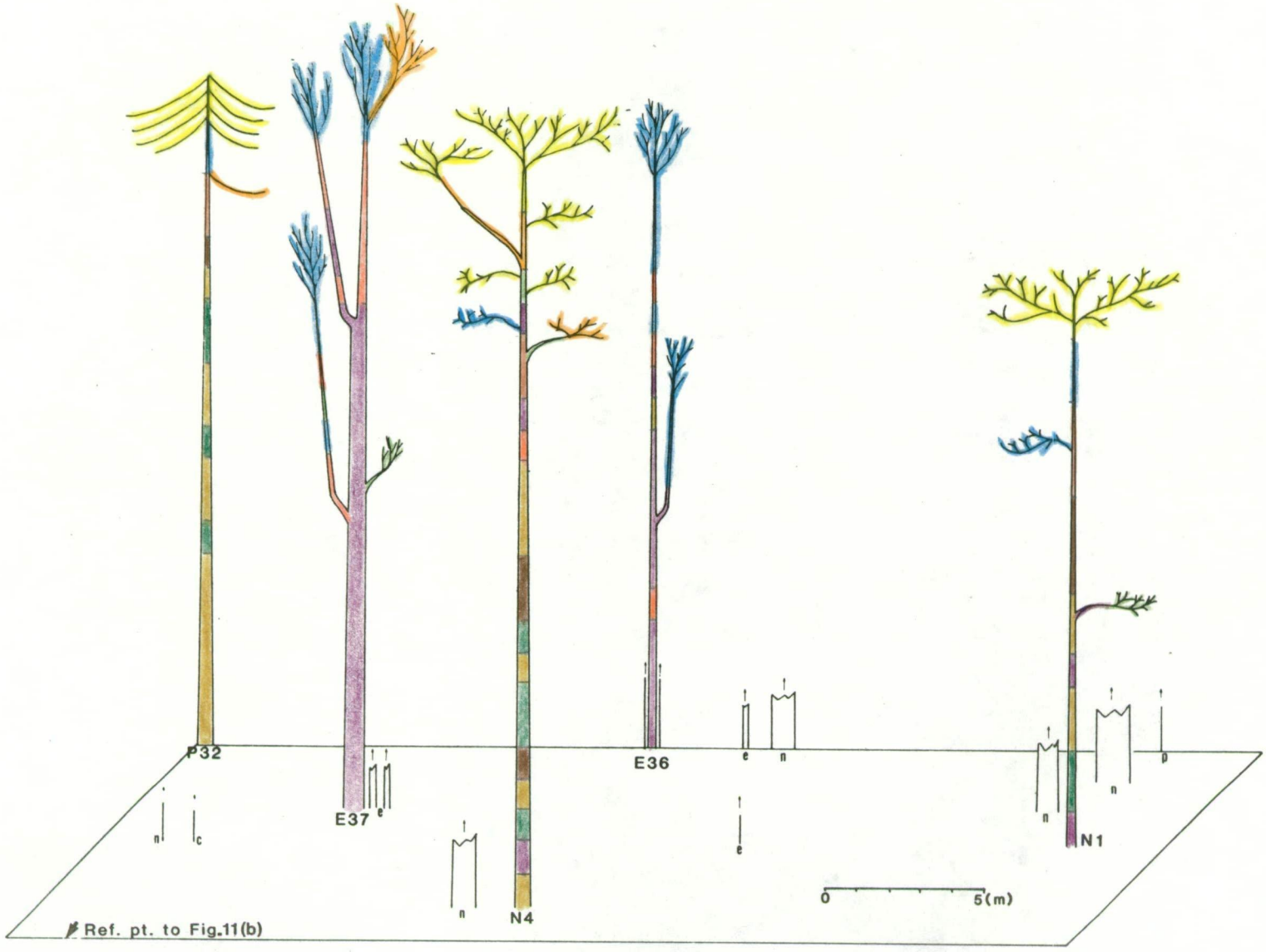



Figure 11(a).

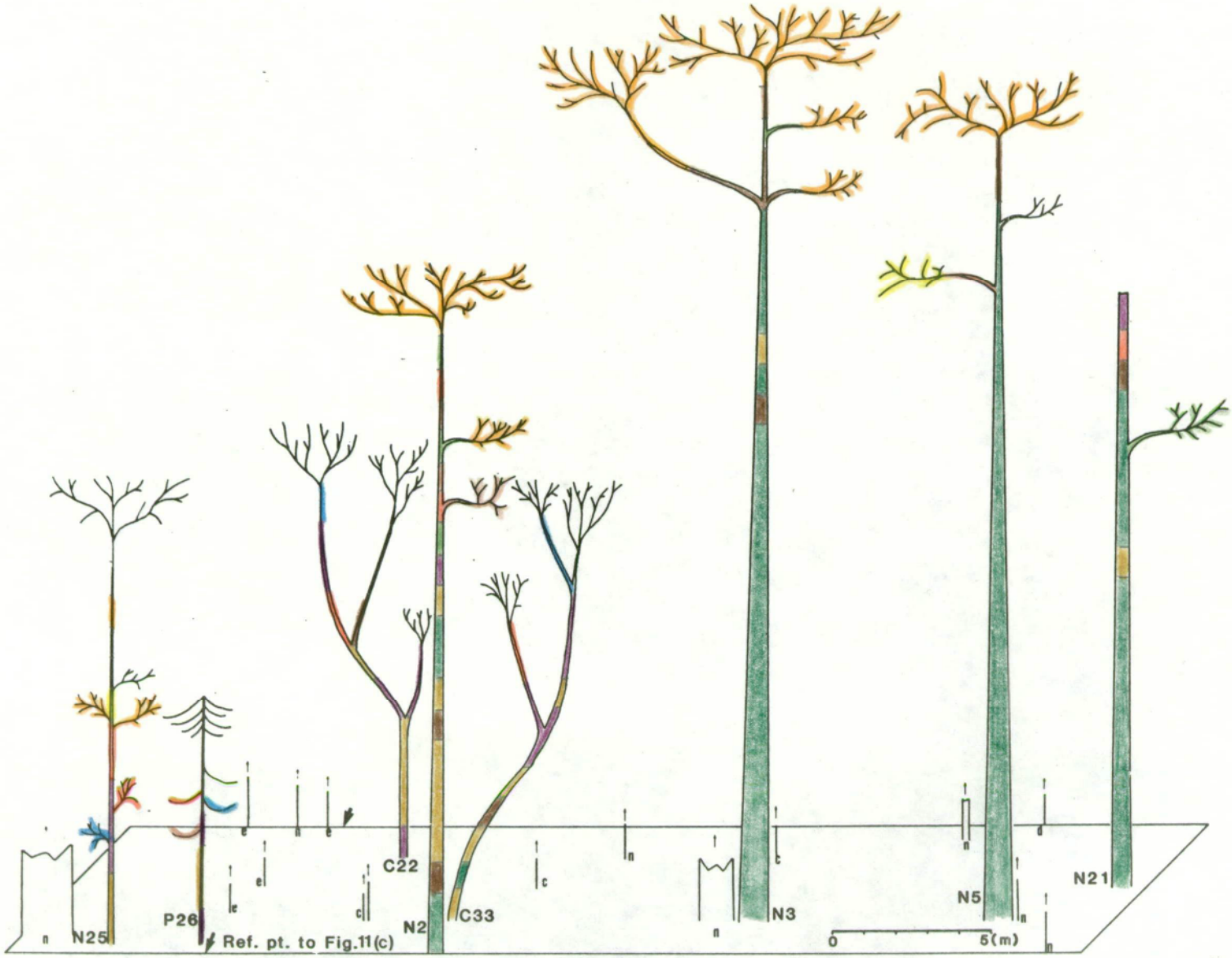



Figure 11(b).

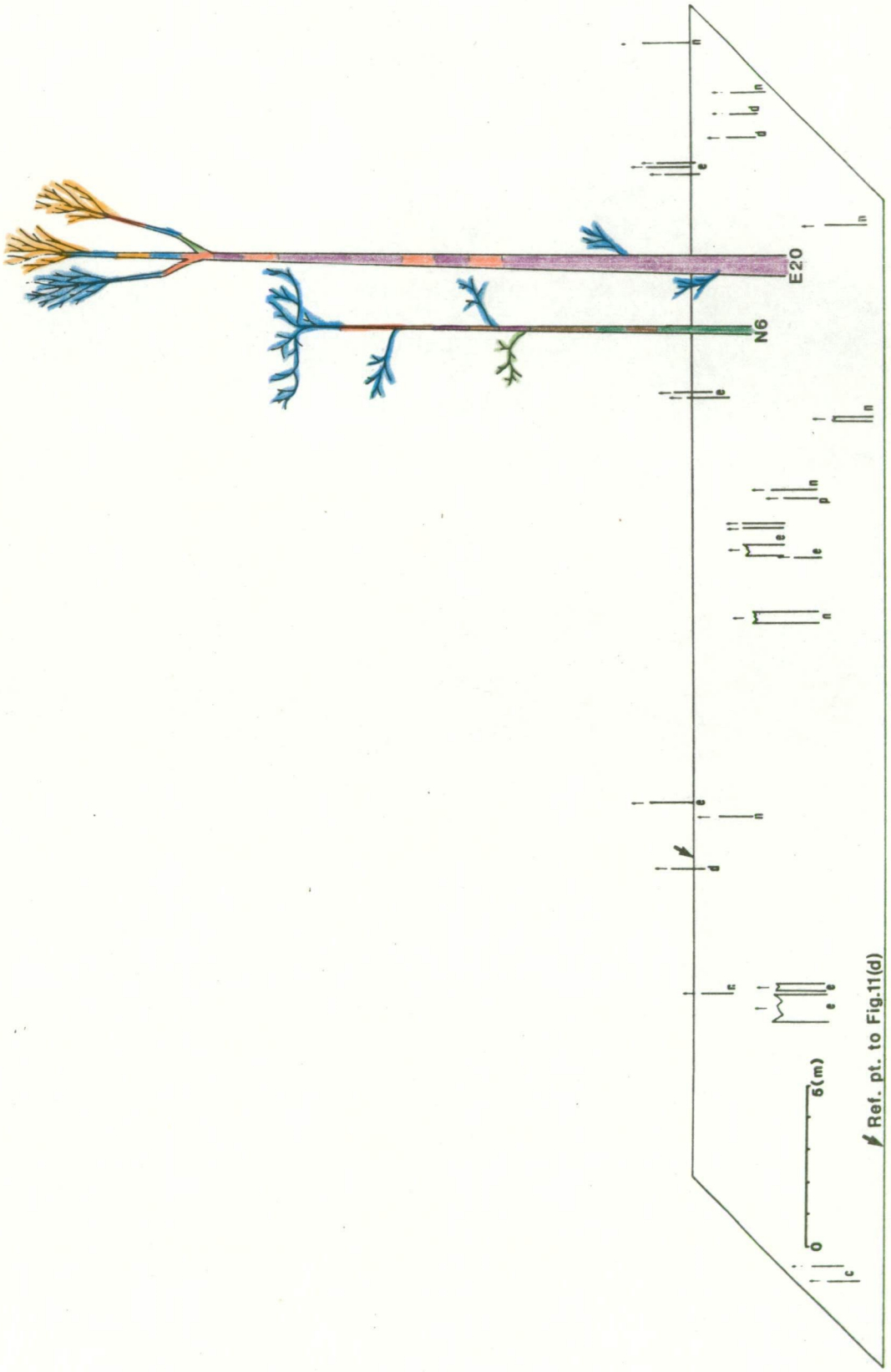



Figure 11(c).


Figure 11(d).

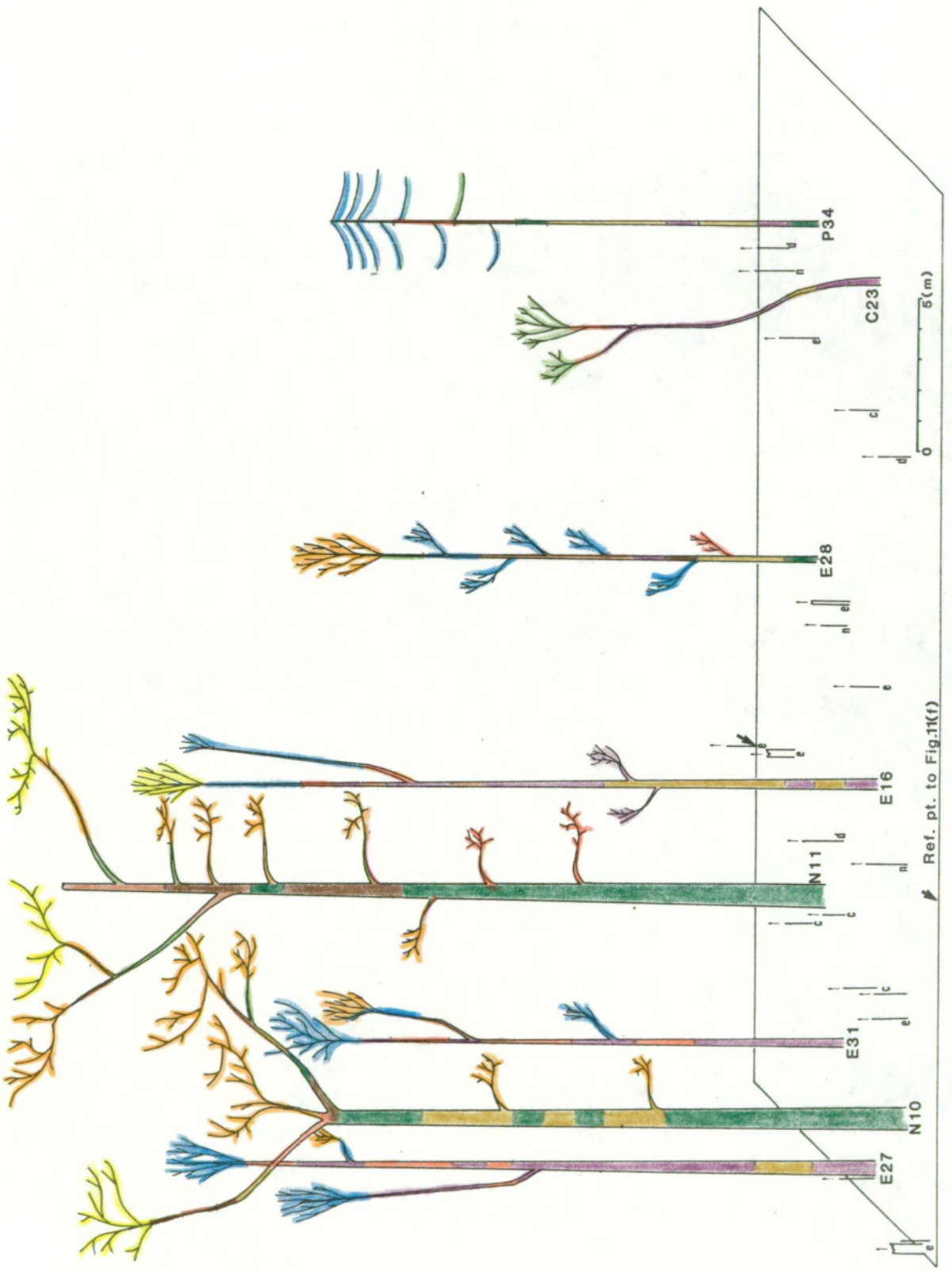



Figure 11(e).

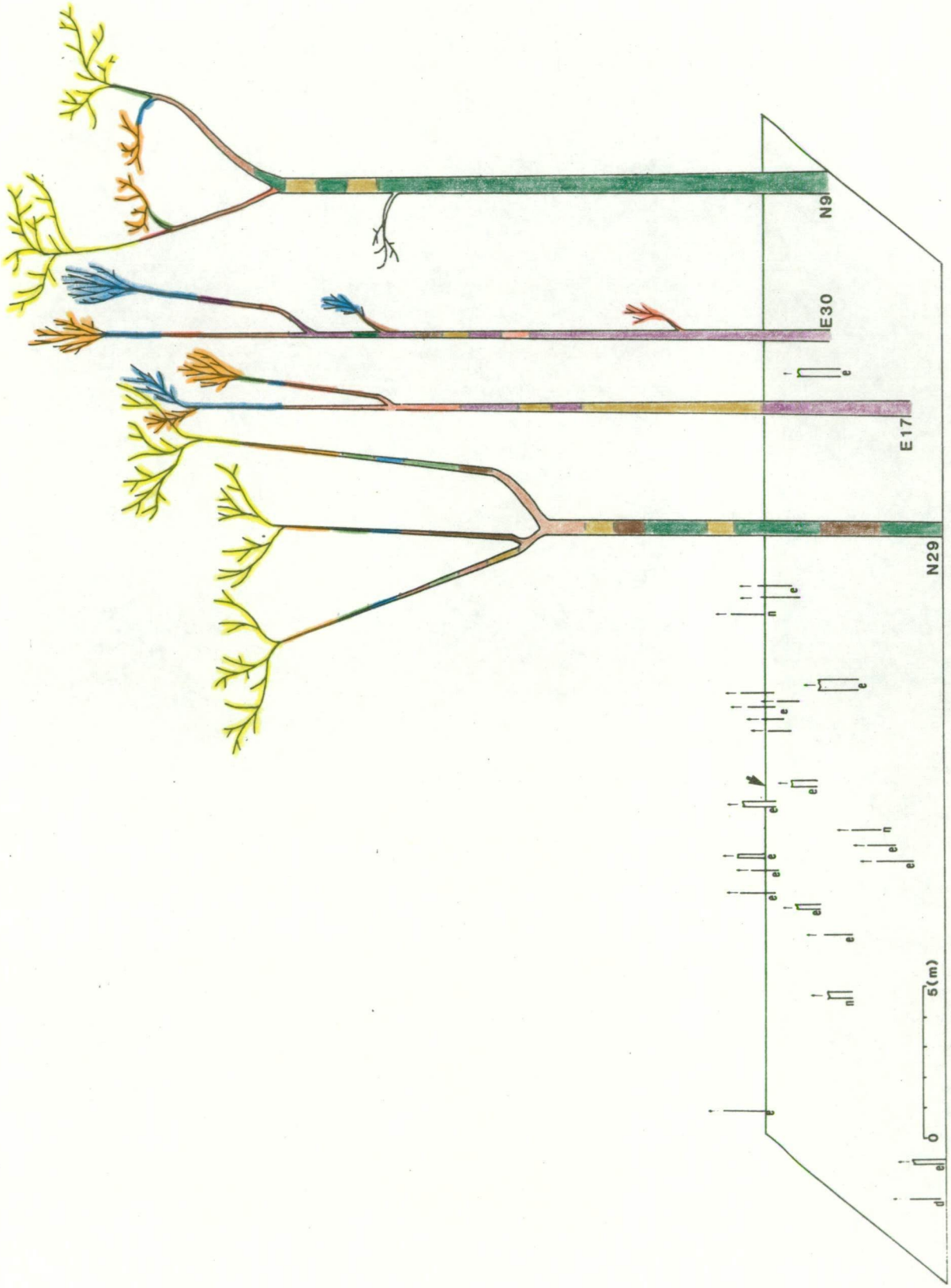



Figure 11(f).

## 9. Zonation in other Tasmanian rainforests

On the basis of observations across a broad range of rainforest communities, the results from the Sumac Road study are considered typical for most mature, lowland callidendrous or thamnic rainforests.

A pilot study conducted in Nothofagus-Atherosperma rainforest in the Florentine Valley concentrated on young trees felled during a logging operation. Departures from the zonation described for the Sumac Road forest included a significantly lower diversity due to the absence of old-trunk species, a lack of any major differences between host trees (Nothofagus, Atherosperma and Phyllocladus) and a very broad overlap between basal and canopy floras. These differences are attributed to the relative youth of the trees.

Lichen zones are not static and may be displaced upwards or downwards, depending on the rainforest community. For example, along the Pieman River (western Tasmania), rainforests with very moist shady understoreys of Acradenia frankliniae or Archeria eriocarpa revealed an upward shift in the lichen flora. The normally terricolous Pseudocyphellaria dissimilis-Peltigera dolichorhiza community assumed a basal, epiphytic position up to 2m high. (The situation in the canopy could not be studied.) Conversely, in high altitude rainforest, lichens are usually displaced downwards to the extent that some basal communities are eliminated or depressed to forest floor habitats (see part IIIC). Similar shifts in lichen zones are reported in North America by Szczawinsky (1953) and Gough (1975) who attribute this to changes in atmospheric moisture.

### Summary

From the study at Sumac Road, several important aspects of vertical zonation in cool temperate rainforest in Tasmania have become apparent.

(a) "Height on the tree" and "host species" are major causes of variation in the lichen flora. The role of the host tree is best explained in terms of its morphology, including its stature, branching pattern, foliage size and bark structure. Height per se is simply a very approximate index of position on a complex environmental gradient between the forest floor and the

canopy. This gradient consists of a climatic component, comprised of a shift from a shaded, moist climate to an arid, exposed climate, and a substrate component. The latter involves a change from trunks to twigs and, in the case of Nothofagus, from rough to smooth bark. Thus Nothofagus possesses the greatest floristic variation because of its greater height and changing bark morphology.

(b) Most of the lichens tend to have broad, overlapping distributions. However, they also have recognisable optima, either near the base of the trunks, the middle of the trunks or in the canopy. This is in agreement with results from the Northern Hemisphere (see p.73). Similarly, although no discrete, sharply delimited zones are present, it is possible to distinguish aggregations of species which, although they intergrade, characterise particular habitats in the forest with respect to height, substrate age and host tree species.

(c) The Tasmanian situation is also analogous to that found in the Northern Hemisphere in that lichens are generally more abundant in the upper part of the trees. However, the apparent increase in lichens with height is essentially an increase in the abundance of a few species rather than an increase in species richness. Because of the marked floristic differences between the bases of tree trunks and the canopy, it is necessary to study entire trees in order to encompass the full range of lichen species present at any one site.

(d) Position in the forest with respect to other trees may also influence the lichen flora of a tree, particularly in so far as this affects local climatic conditions. Thus the lichen "zones" are not static, again in accordance with Northern Hemisphere results (p.73). The proximity to a source of lichen diaspores may also be important, although further studies are required to test this hypothesis.

(e) Succession is evident both at a single height as the tree ages, and along the height gradient as the tree grows taller and successive levels become overtopped and shaded. Whilst the

ultimate climax may be the same, the successional pathway along the height gradient is more complex because it entails the effects of changes in substrate (essentially succession at a single level) as well as changes in climate.

# C. A CLASSIFICATION OF RAINFOREST LICHEN COMMUNITIES AT LITTLE FISHER RIVER

## Introduction

A fundamental problem of vegetation classification is whether plant communities are discrete units (cf. Braun-Blanquet 1932) or whether they are simply part of a continuum (cf. Curtis 1955). James et al. (1977) maintain that "groupings can be recognised ...[although some stands]...may be intermediate". These authors (loc. cit. p.298) state that "phytosociology should aim to determine those major noda in the continuum of plant communities which are related to clearly recognisable ecological...parameters, rather than to fit all stands...into a rigid system of too strictly defined associations". This view is accepted in the present study which attempts to determine and describe the major noda in the lichen flora of the Little Fisher Valley, northern Tasmania. The resulting classification is intended to provide a framework which, in the future, could be expanded to encompass rainforest lichen communities throughout Tasmania. The study represents the first of its kind on any lichen vegetation in Tasmania or elsewhere in the Southern Hemisphere.

Two basic approaches have been employed in the classification of vegetation. The traditional approach has been phytosociological, essentially using the technique of tabular comparison of quadrat data. This technique is exemplified by the Zurich-Montpelier school and is described in detail by Mueller-Dombois and Ellenberg (1974). Several lichen studies have been undertaken using this approach, notably those of Barkman (1958) in western Europe and James et al. (1977) in Britain. The approach is recommended for general use by Hawksworth (1974). A particular difficulty of the phytosociological approach is the assigning of valid, latinised hierarchical names to the units of classification (Hawksworth 1974, James et al. 1977). This task is essentially the endpoint of a broadly-based, highly refined classification. Whilst considerable progress towards a formal scheme is made in the present study, the establishment of such a scheme is delayed pending additional systematic sampling in other rainforests to assess the variability of the vegetation units which have been recognised.

The alternative approach to vegetation classification is numerical. This approach has become increasingly popular in ecology, partly due to the proliferation of computers and their ability to handle large data sets. Several methods for quantitative analysis are available [e.g. see Frenkel and Harrison (1974) for reviews] and examples of their application to lichenology are cited by Ferry (1982).

In the present study, phytosociological and numerical strategies are employed in what is regarded as a complementary manner. A brief discussion of their relative merits is also provided.

**The study area**

The study area is located along the upper reaches of the Little Fisher River, northern Tasmania, and is situated at an elevation of 840-900 m with an annual rainfall of approximately 2800 mm (Bureau of Meteorology data for Cradle Valley, c. 35 km to the north-west). The Little Fisher Valley is a deep north-west facing cleft in the northern rim of the Central Plateau. The valley floor carries pure rainforest with Eucalyptus delegatensis open sclerophyll forest on the rocky slopes beneath the sheer dolerite bluffs of the plateau.

The study site consists of approximately 100 ha of virgin rainforest along the western bank of the river. At the lower (northern) boundary, the valley opens out into eucalypt forest where some logging has occurred. The upper (southern) boundary is marked by a large waterfall.

The rainforest is an excellent example of high altitude callidendrous forest (see p.15) and consists of a closed canopy of pure Nothofagus cunninghamii 18-22 m tall. The understorey is clear and shrubs are uncommon, Telopea truncata and Tasmannia lanceolata being the main species. Atherosperma moschatum is common in narrow bands along drainage channels and on the river bank. The trunks of Nothofagus are typically crooked and leaning. Rotting stumps and logs of eucalypts are scattered through the forest, indicating that the community has developed relatively recently from "mixed forest" (see p.12). Where dead, standing eucalypts occur, the Nothofagus trees are younger and appear to be even-aged. In other places, the Nothofagus is very large and old and there is no evidence of eucalypts. The ground surface is covered with fine litter or mosses, interspersed with local patches of Libertia pulchella and Blechnum

penna-marina. Hymenophyllum peltatum is common on rock outcrops whilst clearings may support Lycopodium fastigiatum and cushions of Cladina confusa. Boggy areas are dominated by large mounds of Sphagnum sp.

This site was selected on the basis of its extremely well-developed and diverse lichen flora which enabled many lichen communities to be studied in their optimum form. The low diversity of trees and shrubs present ensured that succession and variability in the epiphytic lichen flora was not greatly complicated by the effects of different substrates.

**Sampling**

The emphasis of the study was on the epiphytic lichen flora and on the allied vegetation of buttresses, logs etc. Some non-systematic sampling was also undertaken of the lichen communities on the forest floor and on the occasional rotting eucalypt stumps present in the forest. However, these communities are virtually unrelated floristically to the epiphytic vegetation. Furthermore, they are essentially fragmented forms of non-rainforest vegetation and their detailed study would best be undertaken at a site where they are better developed (see also p.158).

Quadrats were located subjectively with the aim of sampling the full range of epiphytic lichen vegetation. The quadrats were of variable size, ranging approximately from 10 x 1 cms on twigs to 180 x 100 cms on the largest trunks. Size and location of the quadrats were determined by two criteria: firstly, that the vegetation within the quadrat was homogeneous and secondly, that the habitat was homogeneous. A region of vegetation was considered homogeneous if no consistent floristic differences were apparent between sub-areas within it (cf. Minchin 1983). Note that a quadrat can be intermediate between two noda but still be homogeneous. Furthermore, a single vegetation type extending over, for example, a trunk, buttress and the forest floor was never included in a single quadrat. Within this framework, quadrats were located to include clearly evident vegetation units (often allied to equally obvious habitat types), as well as a range of apparently intermediate vegetation.

Most sampling was confined to the lowest 2 m of the forest, a height which represents the practical limit to accessibility. Exceptions included isolated instances where recently fallen trees or

limbs were sampled. Cover of all lichen species in each quadrat was recorded using the Braun-Blanquet scale, slightly modified for entry of the data into a computer (see Table 9). Individual bryophytes were combined to form a single performance score for each quadrat. However, the dominant species were noted. Numerous collections of lichens and bryophytes were made for checking and/or identification in the laboratory.

Several environmental parameters were also recorded where applicable. In the case of epiphytic quadrats, these included the host species, the diameter of the trunk or limb being sampled, the aspect (compass bearing) and inclination of the bark surface (angles <90° are inclined towards the observer), as well as subjective assessments of bark texture and dryness. Position of the tree in the forest, e.g. its proximity to other trees or creeks, degree of exposure etc., was also noted. Not all these factors could be assessed for quadrats from fallen limbs. For non-epiphytic quadrats, the substrate (peat or rock), aspect, slope and subjective assessments of dryness were noted.

Table 9. Comparison of scales used for recording cover in the Little Fisher River study.

| % cover | Braun - Blanquet cover class scale (Mueller - Dombois & Ellenberg 1974) | modified Braun - Blanquet scale | cover class midpoint (% cover) |
|---|---|---|---|
| insignificant | + | 1 | 0.001 |
| <5 | 1 | 2 | 2.5 |
| 5-25 | 2 | 3 | 15.0 |
| 25-50 | 3 | 4 | 37.5 |
| 50-75 | 4 | 5 | 62.5 |
| 75-100 | 5 | 6 | 87.5 |

## PHYTOSOCIOLOGY

### Methods

After preliminary reconnaissance work, intensive sampling was undertaken during six field trips, amounting to approximately 25 days in the field. Between field trips, identifications were checked and the data sorted into provisional groups. These proposed groupings were then compared with those gained using the numerical classification method, Two-way Indicator Species Analysis [Twinspan (Hill 1979a), see Appendix 2]. This method occasionally suggested additional groups in the data which had not been initially recognised in the field. Several data-handling computer programs (P. Minchin unpubl.) were also employed in these early stages of the work for the construction of ordered tables and extracting species statistics. On subsequent field trips, the aims were

a) to re-examine the proposed classes in the field and refine them on the basis of additional data and first-hand descriptions,
b) supplement data for any under-sampled classes,
c) to re-examine the study area in the light of the proposed classification to check that no communities had been omitted, and
d) to make notes on the variability of the communities and the relationships and dynamics between them.

Thus with each field trip, the concept of likely communities was continually refined and adjusted.

Ultimately, 331 quadrats were collected but from these a subset of 191 quadrats was compiled (hereafter called the "select data"). This was achieved by the exclusion of many duplicates of the more common vegetation types, several clearly intermediate quadrats and those terricolous or saxicolous quadrats which were floristically unrelated to the epiphytic flora. Thus a manageable data set was formed which contained more balanced numbers of quadrats from each community but nevertheless represented the full range of variation in the data. For the final classification, the "select data" was manually arranged into classes by tabular comparison [cf. Mueller-Dombois and Ellenberg (1974), pp. 174-209].

**Results and discussion**

127 species of lichens were recorded in the study area (see Table 10). In addition to isolated occurrences of some non-rainforest species from the adjacent eucalypt forest (Cladonia carassensis, C. corniculata, C. pleurota, Lecidea leptocarpa and Stereocaulon corticatulum), the flora contains 59% of the total number of lichens recorded from Tasmanian rainforest as a whole. General features of the lichen flora of this type of rainforest community are given on p.68.

1. Epiphytic vegetation

Eleven communities are recognised in the epiphytic rainforest lichen flora. These are described below. Summary statistics of "mean percentage cover" and "frequency" for the more common species in each community (i.e. species with a frequency >20% in at least one community) are given in Tables 11 and 12 respectively. The species have been arranged into groups which are characteristic of each community. Ideally, character species (after Shimwell 1970, p.210) have their highest cover and frequency in their particular community, a criterion which holds in all but a few cases. Provisional names are ascribed to the communities on the basis of the most common, most prolific (hence conspicuous) and most faithful species. Complete inventories of the composition of each community are given in Tables 13-23. These tables show the percentage cover of the species, scored according to the modified Braun-Blanquet scale (Table 9). A network of inter-relationships between the communities is proposed in figure 12.

**THE COMMUNITIES**

(1) Lecanactis abietina - Sagenidium molle community (Table 13)

This community forms the climax vegetation of very dry fissured bark. Its host phorophyte is mostly Nothofagus cunninghamii, a species which best combines the characteristics of massive girth, leaning habit and fissured bark which result in suitably dry aspects. The best habitats occur on the underhanging faces of trunks greater than 40 cm diameter, inclined up to 25° from the vertical and with a surface of loosely attached, thick plates of bark. The direction of the lean does not appear to be related to any particular compass

Table 10. A list of lichens recorded from the Little Fisher River study area showing the vegetation type in which each species has been recorded. Nos. 1-11 refer to the communities described in the text. The symbols 'G' and 'E' refer to the ground and Eucalyptus respectively. Figures or symbols in parentheses signify an uncommon occurrence.

Arthonia cinereopruinosa 1,(2)
Arthonia sp.1 1,2
Arthonia sp.2 10
Arthothelium sp.1 (4),(7),10
A. ilicinum 10
Austroblastenia pauciseptata (4),(8),10
Bacidia buchananii 5
Bacidia weymouthii (6),(7),(8),10
Baeomyces heteromorphus G
Catillaria sp.1 9,10,(11)
Catillaria sp.3 1,2,(4)
Catillaria sp.4 1,(2)
Catinaria sp. (7),9,10,(11)
C. pulverea (4),(7),(10)
Cetraria chlorophylla (2),9,(10),(11)
Chaenotheca brunneola 1
Chiodecton colensoi (6),(7),10
Cladia aggregata (2),3,4,5,6,(7),(8),G
Cladina confusa G
Cladonia carassensis G
C. chlorophaea 3,(4),(5),(6),G
C. corniculata G
C. ochrochlora (1),(2),3,4,(5),(6),(7),(8),(9)
C. pleurota G
C. scabriuscula 5,G
C. squamosula E
C. subdigitata G,E
Cliostomum griffithii 1,(10)
Coccotrema cucurbitula (4),(6),(7),(8),(9),10,(11)
Coenogonium implexum (6),(7)
Collema laeve (6),(7),(8)
Coniocybe furfuracea 1,(2)
Conotremopsis weberiana (1),2,(4)
Dendriscocaulon dendriothamnodes (3),5,(6),(7),(8),G
Dimerella lutea (6),(7),(10)
Fuscidea sp. 11
Gymnoderma melacarpum E,G
Haematomma infuscum (10),11
Hypogymnia lugubris 9,11
H. mundata 9,11
H. subphysodes (4),9,(10),11
H. turgidula (2),(4),(8),9,(10),11
Lecanactis abietina 1,(2)
Lecanora atra (10),11
Lecidea cf. granulosa E
L. laeta 11
L. leptocarpa G
Lecidea sp.1 9,(10),11
Lecidea sp.4 1
Lecidella elaeochroma aggr. 9,(10),11
Leioderma amphibolum (2),(3),(4),(6),(7),8,9
Lepraria incana 1,2,(3),4,(5),(6),(7),(8),(9),(10),G,E
L. membranacea 1
Leptogium limbatum (3),5,G
L. victorianum 5,G
?Lopadium sp. (1)
Megaloblastenia marginiflexa (8),10
Menegazzia caliginosa (9),(10),(11)
M. globulifera (4),(8),9,(11)
M. nothofagi (7),(8),(9),(10)
M. platytrema (9),11
M. retipora (9),11
M. ultralucens (8),(9),11
M. weindorferi (2),(4),(8),9,(10),11
Micarea mutabilis 2,4,(9)
M. prasina aggr. 2,4,(9)
Mycoblastus sp.1 9,11
Nephroma australe (6),7,8
Ochrolechia sp. (10),11
Opegrapha stellata (4),(7),(8),(9),10
Pannoparmelia angustata 9,11
Parmelia cunninghamii (2),(4),(8),9,(10),(11)
P. labrosa (9),(10),11
P. cf. revoluta (10),11
P. subglabra (9),(10),11
P. tenuirima (6),(7),(8),9,(10),(11)
P. testacea (4),(8),9,(10)
Parmeliella nigrocincta aggr. (4),(5),6,7,(8)
Peltigera dolichorhiza 5,G
Pertusaria sp.1 (3),(9)
P. cf. nothofagi (2),(4),(7),(8),9,10,11
Phlyctella subuncinata (4),(7),(8),10
Phyllopsora congregans 3,(4)
Pilophorus conglomeratus 3
Placopsis gelida (5),G
Porina leptaleina (2),(4)
Pseudocyphellaria argyracea aggr. (3),(4),(6),(7),(8)
P. billardieri (5),(6),7,8,(10)
P. colensoi (4),8
P. crocata 3,5,(7),8,G
P. delisea (2),3,4,5,6,7,8,(9),(10),G
P. dissimilis 5,(6),G
P. faveolata 8
P. cf. insculpta 5,6,G
P. rubella 8
P. subvariabilis 5,6,(7),G
Psilolechia lucida (G)
Psoroma asperellum (2),3,4,(6),(7),(8)
P. durietzii (3),(4),(6),(7),8,(9)
P. leprolomum 8,(9)
P. microphyllizans (2),3,4,5,6,7,8,(9),(10),G
P. paleaceum 3,(6),(7),(8)
P. pholidotoides 7,(8)
Psoroma sp.1 (6),(7),(8)
Psoromidium aleuroides (6),7,(8)
P. versicolor (8),(10)
Pyrenula sp. 10
Ramonia muscicola 4,(7),(10)
Rinodina dissa (9)
Sagenidium molle 1,2
Scoliciosporum cf. pruinosum (2),(4)
Sphaerophorus insignis (2),3,4,(5),6,(7)
S. melanocarpus 3,(4),(5),(6)
S. patagonicus 3,(4),(6)
S. ramulifer 2,3,4,(6),(7),(8),(10)
S. tener 2,3,4,5,6,(7),8,9,10,(11),G
Stereocaulon corticatulum (G)
S. ramulosum (5),G
Sticta stipitata 3,(4),5,6,7,(8),G
S. sublimbata (8)
Thelotrema lepadinum 1,2,3,4,(5),6,7,(8),(9),10
T. subdenticulatum 3,(4),(5),(6)
Usnea arida 9,11
U. capillacea (11)
U. molliuscula 11
Usnea sp. (2),(4),(8),9,(10),11
Species B 10

Table 11. An ordered two-way table showing frequency of common species in 11 rainforest epiphytic communities.

| | SPECIES | COMMUNITIES* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| ubiquitous species | Thelotrema lepadinum | 100 | 80 | 59 | 80 | 8 | 55 | 88 | 14 | 15 | 88 | - |
| | Lepraria incana | 80 | 95 | 24 | 44 | 8 | 27 | 18 | 21 | 45 | 12 | - |
| Characteristic species of community no. 1 | Chaenotheca brunneola | 55 | - | - | - | - | - | - | - | - | - | - |
| | **Lecanactis abietina** | 95 | 5 | - | - | - | - | - | - | - | - | - |
| | Coniocybe furfuracea | 65 | 5 | - | - | - | - | - | - | - | - | - |
| | Arthonia cinereopruinosa | 40 | 5 | - | - | - | - | - | - | - | - | - |
| | **Sagenidium molle** | 65 | 30 | - | - | - | - | - | - | - | - | - |
| | Arthonia sp. 1 | 50 | 65 | - | - | - | - | - | - | - | - | - |
| 2 | **Conotremopsis weberiana** | 10 | 95 | - | 16 | - | - | - | - | - | - | - |
| | Micarea mutabilis | - | 70 | 6 | 16 | - | - | - | - | 5 | - | - |
| | Phyllopsora congregans | - | - | 47 | 8 | - | - | - | - | - | - | - |
| | **Sphaerophorus insignis** | - | 30 | 100 | 52 | - | 55 | 24 | - | - | - | - |
| 3 | Psoroma asperellum | - | 10 | 53 | 28 | - | 27 | 6 | 7 | - | - | - |
| | Thelotrema subdenticulatum | - | - | 47 | 4 | 8 | 9 | - | - | - | - | - |
| | Cladia aggregata | - | 10 | 88 | 20 | 25 | 36 | - | - | - | - | - |
| | Cladonia ochrochlora | 5 | 25 | 36 | 56 | - | 9 | 6 | 14 | 20 | - | - |
| 4 | **Sphaerophorus ramulifer** | - | 70 | 71 | 80 | - | 18 | - | 14 | - | 4 | - |
| | **Sphaerophorus tener** | - | 45 | - | 100 | 42 | 45 | 41 | 79 | 40 | 48 | 10 |
| | Pseudocyphellaria delisea | - | 20 | 94 | 96 | 50 | 82 | 82 | 100 | 50 | 48 | - |
| | Cladonia scabriuscula | - | - | - | - | 33 | - | - | - | - | - | - |
| | **Peltigera dolichorhiza** | - | - | - | - | 67 | - | - | - | - | - | - |
| 5 | Dendriscocaulon dendriothamnodes | - | - | 6 | - | 25 | - | - | 7 | - | - | - |
| | Leptogium limbatum | - | - | 6 | - | 42 | - | - | - | - | - | - |
| | **Pseudocyphellaria dissimilis** | - | - | - | - | 84 | 27 | - | - | - | - | - |
| | Sticta stipitata | - | - | 6 | 4 | 75 | 64 | 47 | 8 | - | - | - |
| | Sphaerophorus melanocarpus | - | - | 12 | 16 | - | 27 | - | - | - | - | - |
| 6 | **Pseudocyphellaria subvariabilis** | - | - | - | - | 42 | 100 | 6 | - | - | - | - |
| | **Psoroma microphyllizans** | - | 5 | 24 | 68 | 67 | 82 | 100 | 36 | 35 | 32 | - |
| 7 | **Pseudocyphellaria billardieri** | - | - | - | - | 25 | 9 | 94 | 86 | - | 4 | - |
| | Parmeliella nigrocincta | - | - | - | 12 | 17 | - | 35 | - | - | - | - |
| | Psoroma durietzii | - | - | 6 | 24 | - | 9 | - | 50 | - | 12 | - |
| | Nephroma australe | - | - | - | - | - | 9 | 12 | 64 | - | - | - |
| 8 | **Pseudocyphellaria faveolata** | - | - | - | - | - | - | - | 71 | - | - | - |
| | **Pseudocyphellaria rubella** | - | - | - | - | - | - | - | 71 | - | - | - |
| | Psoroma leprolomum | - | - | - | - | - | - | - | 36 | - | - | - |
| | Leioderma amphibolum | - | 10 | 24 | 24 | - | - | 6 | 14 | 50 | - | - |
| | **Parmelia testacea** | - | - | - | 24 | - | - | - | 7 | 80 | 4 | - |
| | Parmelia tenuirima | - | - | - | - | - | 9 | 6 | 14 | 70 | 4 | 20 |
| 9 | Parmelia cunninghamii | - | 5 | - | 4 | - | - | - | 7 | 30 | 4 | 10 |
| | **Pertusaria nothofagi** | - | 5 | - | 24 | - | - | 12 | 21 | 90 | 36 | 60 |
| | Menegazzia weindorferi | - | 5 | - | 8 | - | - | - | 36 | 100 | 20 | 80 |
| | Usnea sp. | - | 5 | - | 20 | - | - | - | 29 | 50 | 24 | 50 |
| | Catinaria sp. | - | - | - | - | - | - | 6 | - | 25 | 24 | 20 |
| | **Coccotrema cucurbitula** | - | - | - | 12 | - | 9 | 18 | 36 | 15 | 64 | 10 |
| | **Opegrapha stellata** | - | - | - | 28 | - | - | 12 | 7 | 10 | 96 | - |
| 10 | Austroblastenia pauciseptata | - | - | - | 8 | - | - | - | 7 | - | 48 | - |
| | Bacidia weymouthii | - | - | - | - | - | - | 12 | 7 | - | 52 | - |
| | Chiodecton colensoi | - | - | - | - | - | - | 6 | - | - | 40 | - |
| | Species B | - | - | - | - | - | - | - | - | - | 32 | - |
| | Hypogymnia turgidula | - | 5 | - | 16 | - | - | - | 7 | 50 | 4 | 60 |
| | Parmelia labrosa | - | - | - | - | - | - | - | - | 10 | 28 | 70 |
| | Parmelia subglabra | - | - | - | - | - | - | - | - | 5 | 20 | 40 |
| 11 | Menegazzia retipora | - | - | - | - | - | - | - | - | 5 | - | 40 |
| | **Pannoparmelia angustata** | - | - | - | - | - | - | - | - | 15 | - | 90 |
| | Ochrolechia sp. | - | - | - | - | - | - | - | - | - | 12 | 30 |
| | Haematomma infuscum | - | - | - | - | - | - | - | - | - | 8 | 60 |
| | Fuscidea sp. | - | - | - | - | - | - | - | - | - | - | 40 |
| | Lecidea laeta | - | - | - | - | - | - | - | - | - | - | 50 |
| | Usnea molliuscula | - | - | - | - | - | - | - | - | - | - | 50 |
| | No. of stands | 20 | 20 | 17 | 25 | 12 | 11 | 17 | 14 | 20 | 25 | 10 |

* Key : 1: Lecanactis abietina - Sagenidium molle community; 2: Conotremopsis weberiana community; 3: Sphaerophorus insignis community; 4: S. ramulifer - S. tener community; 5: Pseudocyphellaria dissimilis - Peltigera dolichorhiza community; 6: Pseudocyphellaria subvariabilis - Psoroma microphyllizans community; 7: Pseudocyphellaria billardieri - Psoroma microphyllizans community; 8: Pseudocyphellaria rubella - P. faveolata community; 9: Parmelia testacea - Pertusaria nothofagi community; 10: Opegrapha stellata - Coccotrema cucurbitula community; 11: Pannoparmelia angustata community.

Table 12. An ordered two-way table showing mean percentage cover of common species in 11 rainforest epiphytic communities (+ represents <0.5%).

| | SPECIES | COMMUNITIES* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| ubiquitous species | Thelotrema lepadinum | 10.9 | 13.4 | 1.0 | 7.1 | + | 0.7 | 4.7 | + | + | 16.6 | - |
| | Lepraria incana | 2.9 | 7.8 | + | 0.6 | + | + | + | + | + | + | - |
| Character-istic species of community no. 1 | Chaenotheca brunneola | 6.0 | - | - | - | - | - | - | - | - | - | - |
| | **Lecanactis abietina** | 34.8 | + | - | - | - | - | - | - | - | - | - |
| | Coniocybe furfuracea | 1.0 | + | - | - | - | - | - | - | - | - | - |
| | Arthonia cinereopruinosa | 2.3 | + | - | - | - | - | - | - | - | - | - |
| | **Sagenidium molle** | 12.0 | + | - | - | - | - | - | - | - | - | - |
| | Arthonia sp. 1 | 1.6 | 6.9 | - | - | - | - | - | - | - | - | - |
| 2 | **Conotremopsis weberiana** | + | 11.5 | - | + | - | - | - | - | - | - | - |
| | Micarea mutabilis | - | 9.1 | + | + | - | - | - | - | + | - | - |
| | Phyllopsora congregans | - | - | 1.6 | + | - | - | - | - | - | - | - |
| | **Sphaerophorus insignis** | - | + | 24.3 | 0.6 | - | 4.6 | + | - | - | - | - |
| 3 | Psoroma asperellum | - | + | 2.1 | 0.9 | - | + | + | 1.1 | - | - | - |
| | Thelotrema subdenticulatum | - | - | 1.1 | + | + | + | - | - | - | - | - |
| | Cladia aggregata | - | + | 3.0 | 0.8 | 1.7 | + | - | - | - | - | - |
| | Cladonia ochrochlora | + | + | 0.6 | 0.8 | - | + | + | + | + | - | - |
| 4 | **Sphaerophorus ramulifer** | - | 1.6 | 2.2 | 11.7 | + | 1.6 | - | + | - | + | - |
| | **Sphaerophorus tener** | - | 0.5 | 11.0 | 25.0 | 2.9 | 2.1 | 1.9 | 5.0 | 5.0 | 0.5 | 1.5 |
| | Pseudocyphellaria delisea | - | + | 5.3 | 11.7 | 5.2 | 3.2 | 3.1 | 6.1 | 1.9 | 1.3 | - |
| | Cladonia scabriuscula | - | - | - | - | 0.6 | - | - | - | - | - | - |
| | **Peltigera dolichorhiza** | - | - | - | - | 3.3 | - | - | - | - | - | - |
| 5 | Dendriscocaulon dendriotham-nodes | - | - | + | - | 0.6 | - | - | + | - | - | - |
| | Leptogium limbatum | - | - | + | - | 2.7 | - | - | - | - | - | - |
| | **Pseudocyphellaria dissimilis** | - | - | - | - | 32.9 | + | - | - | - | - | - |
| | Sticta stipitata | - | - | + | + | 1.5 | 2.5 | 1.2 | + | - | - | - |
| | Sphaerophorus melanocarpus | - | - | + | + | - | 2.7 | - | - | - | - | - |
| 6 | **Pseudocyphellaria subvariabilis** | - | - | - | - | 4.8 | 37.5 | - | - | - | - | - |
| | **Psoroma microphyllizans** | - | + | 1.2 | 4.7 | 4.6 | 7.3 | 26.5 | 2.5 | 0.6 | + | - |
| 7 | **Pseudocyphellaria billardieri** | - | - | - | - | 1.5 | + | 14.6 | 13.2 | - | + | - |
| | Parmeliella nigrocincta | - | - | - | + | + | - | 1.6 | - | - | - | - |
| | Psoroma durietzii | - | - | + | + | - | + | - | 0.9 | - | - | - |
| | Nephroma australe | - | - | - | - | - | + | + | 4.3 | - | - | - |
| 8 | **Pseudocyphellaria faveolata** | - | - | - | - | - | - | - | 14.5 | - | - | - |
| | **Pseudocyphellaria rubella** | - | - | - | - | - | - | - | 13.6 | - | - | - |
| | Psoroma leprolomum | - | - | - | - | - | - | - | 1.8 | - | - | - |
| | Leioderma amphibolum | - | + | + | + | - | - | + | + | + | - | - |
| | **Parmelia testacea** | - | - | - | + | - | - | - | + | 13.7 | + | - |
| | Parmelia tenuirima | - | - | - | - | - | + | + | + | 5.3 | + | + |
| 9 | Parmelia cunninghamii | - | + | - | + | - | - | - | + | 1.4 | + | + |
| | **Pertusaria nothofagi** | - | + | - | + | - | - | + | 1.4 | 25.0 | 3.8 | 6.5 |
| | Menegazzia weindorferi | - | + | - | + | - | - | - | 0.5 | 8.4 | + | 15.5 |
| | Usnea sp. | - | + | - | + | - | - | - | 0.5 | 0.6 | + | 1.3 |
| | Catinaria sp. | - | - | - | - | - | - | + | - | 1.0 | 1.0 | + |
| | **Coccotrema cucurbitula** | - | - | - | + | - | + | 1.0 | 3.6 | + | 9.3 | + |
| | **Opegrapha stellata** | - | - | - | 0.5 | - | - | + | + | 0.9 | 9.0 | - |
| 10 | Austroblastenia pauciseptata | - | - | - | 0.7 | - | - | - | + | - | 5.1 | - |
| | Bacidia weymouthii | - | - | - | - | - | - | + | + | - | 3.6 | - |
| | Chiodecton colensoi | - | - | - | - | - | - | + | - | - | 1.3 | - |
| | Species B | - | - | - | - | - | - | - | - | - | 2.3 | - |
| | Hypogymnia turgidula | - | + | - | + | - | - | - | + | 0.8 | + | 6.5 |
| | Parmelia labrosa | - | - | - | - | - | - | - | - | + | + | 6.8 |
| | Parmelia subglabra | - | - | - | - | - | - | - | - | + | + | 2.3 |
| 11 | Menegazzia retipora | - | - | - | - | - | - | - | - | + | - | + |
| | **Pannoparmelia angustata** | - | - | - | - | - | - | - | - | + | - | 6.0 |
| | Ochrolechia sp. | - | - | - | - | - | - | - | - | - | + | 0.5 |
| | Haematomma infuscum | - | - | - | - | - | - | - | - | - | + | 2.8 |
| | Fuscidea sp. | - | - | - | - | - | - | - | - | - | - | 2.3 |
| | Lecidea laeta | - | - | - | - | - | - | - | - | - | - | 3.8 |
| | Usnea molliuscula | - | - | - | - | - | - | - | - | - | - | 1.0 |
| | No. of stands | 20 | 20 | 17 | 25 | 12 | 11 | 17 | 14 | 20 | 25 | 10 |

* Key: see Table 11.

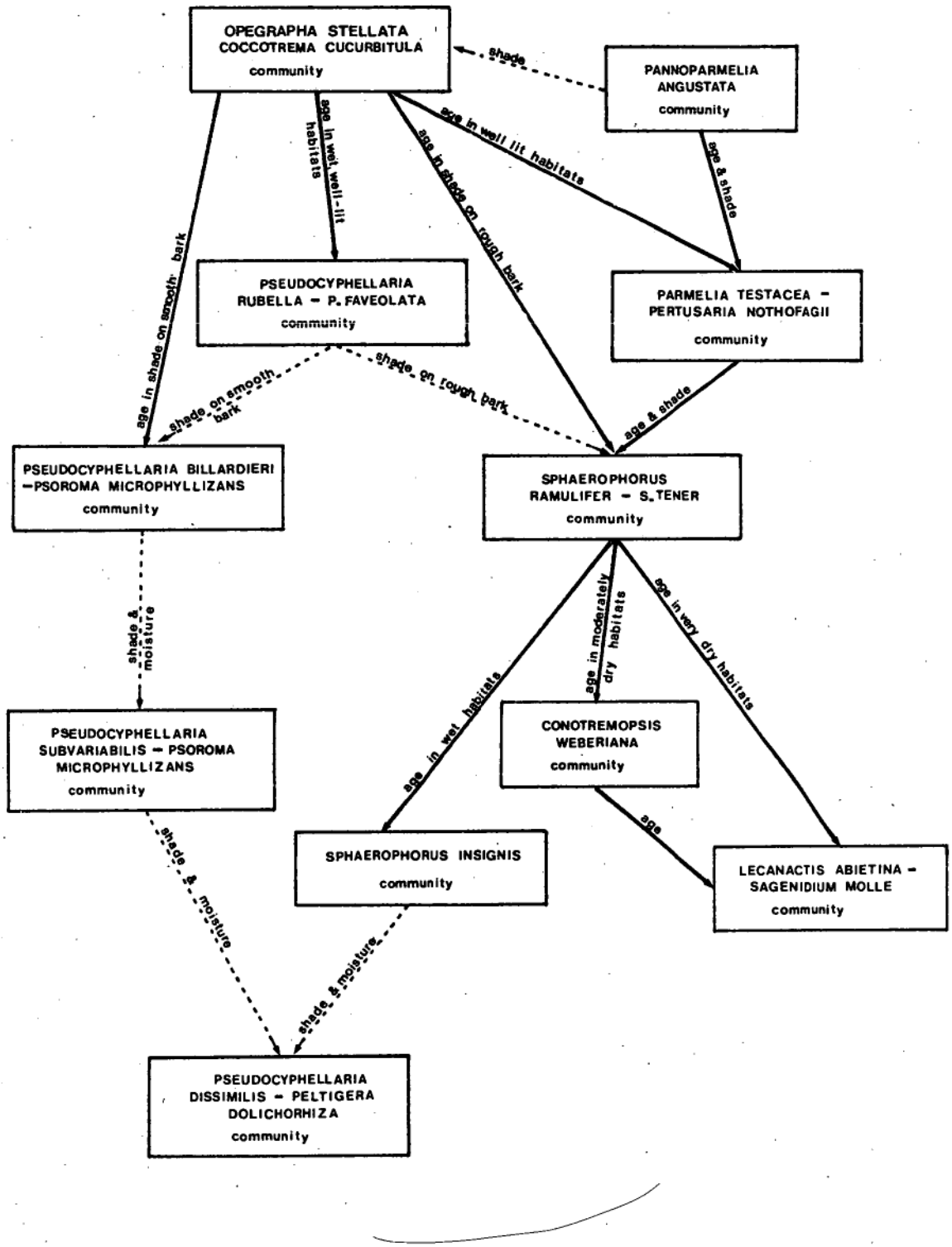



Figure 12. Principal inter-relationships between the epiphytic lichen communities at Little Fisher River. Major successional pathways are shown with solid arrows.

bearing but probably derives from the leaning of trees from early life towards gaps in the canopy. Less commonly, the community is found on nearly vertical trunks where large branches above provide shelter from the rain or runnels of water. It may also occur on the undersides of large limbs or on very exposed trunks along roadsides and at the forest edge.

The dominant character species is usually Lecanactis abietina which may be either abundantly fertile or with pycnidia only. Development of pycnidia appears to be suppressed in fertile individuals. Sagenidium molle is virtually the only macrolichen present and frequently forms very large, roughly circular thalli up to 60 cm across which encroach over the crustose species. Other character species include Coniocybe furfuracea which appears to favour fissures in the bark, Chaenotheca brunneola, and species of Arthonia and Catillaria sens. lat. Lepraria incana is also very common but is not considered characteristic because it is ecologically wide-ranging and is present in locally drier microhabitats within several other communities. It is one of a number of leprose lichens in this community (others include Coniocybe, Chaenotheca, Arthonia cinereopruinosa and Catillaria spp.) which are extremely resistant to wetting, a feature which complements the dryness of their habitat. Thelotrema lepadinum is nearly always present, due to the slow rate of decortication and consequent slow loss of pioneer species on dry aspects. However, its thalli are often in poor condidion, infertile and encrusted with cobwebs, as are those of several other lichens in this community. The identification of such specimens is often difficult and this may have resulted in some rare, but superficially similar, species being overlooked. Bryophytes are rare and typically include only moribund individuals.

The Lecanactis abietina - Sagenidium molle community is very localised in the study area. In several places, it is absent or poorly developed and apparently suitable habitats instead support the Conotremopsis weberiana community (no.2) or intermediate forms between the two. Sagenidium in particular may be noticeably absent. In some of these sites, the forest is younger and dead eucalypt stumps are still present. Thus a well-developed Lecanactis - Sagenidium community may be an indicator of rainforest stands where there has been no disturbance for a very long time.

Table 13. Lecanactis abietina - Sagenidium molle community.

| SPECIES | STANDS * | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 53 | 56 | 57 | 60 | 61 | 113 | 115 | 121 | 156 | 157 | 183 | 192 | 193 | 219 | 229 | 324 | 327 | 328 | 331 |
| Arthonia cinereopruinosa | 2 | - | - | - | 2 | 2 | - | 2 | - | - | 3 | - | 2 | - | - | - | - | 2 | 3 | - |
| Arthonia sp. 1 | 1 | - | 3 | - | - | - | - | - | - | 2 | - | - | 1 | 2 | - | 2 | 2 | 2 | 2 | 2 |
| Catillaria sp. 3 | - | - | 2 | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 2 | 2 | - | - |
| Catillaria sp. 4 | 2 | - | 2 | - | 3 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| Chaenotheca brunneola | 4 | - | - | 3 | 3 | - | - | 3 | - | - | 1 | 2 | 3 | 1 | - | 3 | - | 2 | 2 | - |
| Cladonia ochrochlora | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Cliostomum griffithii | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | 2 | - | - |
| Coniocybe furfuracea | 2 | - | - | 1 | - | 1 | - | 1 | 1 | - | 2 | - | 2 | - | 2 | 1 | 2 | 2 | 2 | 2 |
| Conotremopsis weberiana | 1 | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| **Lecanactis abietina** | **3** | **5** | **2** | **5** | **4** | **4** | **3** | **3** | - | **3** | **5** | **3** | **5** | **5** | **5** | **5** | **4** | **3** | **4** | **3** |
| Lecidea sp. 4 | - | - | - | - | - | - | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| Lepraria incana | 2 | - | 2 | - | - | 2 | 2 | 2 | 1 | 3 | 3 | - | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 |
| Lopadium sp. | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Sagenidium molle** | **3** | **2** | - | - | **2** | - | **2** | - | **5** | **3** | - | **3** | - | - | **3** | **2** | **3** | **3** | **3** | **5** |
| Thelotrema lepadinum | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 4 | 2 | 2 | 3 | 3 | 4 | 3 | 2 | 2 |
| Bryophytes | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | 2 | - | - | - | - | 3 | - |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

The community is widespread in those Tasmanian rainforests which contain large, inclined Nothofagus trees, i.e. most mature callidendrous and thamnic communities. Although best developed on Nothofagus, it has also been recorded from mature Phyllocladus (which has similar, plate-like rough bark) and, rarely, from very old Eucryphia lucida. However, in these cases, the diversity of lichens is usually low and only Sagenidium molle is well-developed. Further detailed sampling is required to assess the extent of variability in this community in Tasmania.

The community displays clear affinities to the Calicion hyperellii alliance on aged dry trunks in Britain (cf. James et al. 1977). As well as a similar habitat, several lichens, e.g. Lecanactis abietina, Lepraria incana, Chaenotheca brunneola, Coniocybe furfuracea and Cliostomum griffithii, are common to both. Despite its highly rainforest-centred distribution in Tasmania, the Lecanactis - Sagenidium community contains an extraordinarily high proportion of temperate Northern Hemisphere taxa and is noticeably impoverished with respect to austral cool temperate species (see also p.30).

(2) Conotremopsis weberiana community (Table 14)

This community occupies an intermediate ecological position between the Lecanactis abietina - Sagenidium molle community (1) and the Sphaerophorus insignis community (3). It occurs on relatively dry bark on trunks where the dry aspect is not fully developed, usually because of the upright nature of the tree or its small girth. Alternatively, it may be found in a narrow transitional zone on the trunk between well-developed climax communities of very wet and very dry aspects. Occasionally it replaces the Lecanactis - Sagenidium community and forms the dominant vegetation on very dry aspects. Although most common on mature Nothofagus, incipient or fragmented stages have been observed on Telopea, Atherosperma and young Nothofagus.

Conotremopsis weberiana and Micarea mutabilis are the major character species. The distinctive, orange, circular thalli of the former make the community easily recognisable. Lepraria incana is also a conspicuous and important component of the community. Arthonia sp.1 is common and appears to be particularly adapted to the smooth secondary surface of the trunk which is exposed by the extensive, active decortication occurring in this habitat. Bryophytes form an

Table 14. Conotremopsis weberiana community.

| SPECIES | STANDS* | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 12 | 38 | 43 | 58 | 77 | 82 | 104 | 124 | 137 | 141 | 146 | 184 | 196 | 197 | 322 | 323 | 325 | 326 | 329 | 330 |
| Arthonia sp. 1 | 2 | - | 1 | - | - | 2 | 1 | 2 | - | - | - | 3 | 2 | 3 | 3 | 3 | 3 | 4 | 3 | - |
| A. cinereopruinosa | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - |
| Catillaria sp. 3 | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 1 | - | 1 | - | 1 | - | - |
| Cetraria chlorophylla | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Cladia aggregata | 2 | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cladonia ochrochlora | - | - | 2 | 1 | - | - | - | - | 1 | - | 1 | - | - | - | - | 2 | - | - | - | - |
| Coniocybe furfuracea | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - |
| **Conotremopsis weberiana** | **3** | **3** | **3** | **2** | **2** | **1** | **2** | **2** | **3** | **2** | **3** | - | **3** | **2** | **5** | **2** | **3** | **3** | **3** | **3** |
| Hypogymnia turgidula | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lecanactis abietina | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| Leioderma amphibolum | - | 2 | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Lepraria incana | - | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 4 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 1 |
| Menegazzia weindorferi | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Micarea mutabilis | - | - | 3 | 2 | 2 | 2 | 2 | - | - | 2 | - | 2 | 3 | 3 | - | 3 | 3 | 3 | 5 | 3 |
| M. prasina aggr. | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Parmelia cunninghamii | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pertusaria nothofagi | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pseudocyphellaria delisea | - | 2 | - | - | - | - | - | - | 1 | - | 1 | - | - | - | 1 | - | - | - | - | - |
| Psoroma asperellum | - | 2 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| P. microphyllizans | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sagenidium molle | 1 | - | - | 1 | - | - | - | 2 | 1 | - | - | - | 2 | 1 | - | - | - | - | - | - |
| Sphaerophorus insignis | - | - | - | 1 | 1 | - | - | 1 | - | - | 1 | - | 1 | - | - | - | - | - | - | 1 |
| S. ramulifer | 2 | - | 1 | - | - | 1 | 3 | 1 | 2 | - | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | - | - |
| S. tener | 2 | 2 | 2 | - | - | - | 1 | - | 2 | - | - | 1 | 1 | - | - | - | 1 | - | - | 1 |
| Thelotrema lepadinum | 3 | - | 3 | 2 | 4 | 4 | 2 | 4 | - | 2 | 2 | 2 | 3 | 5 | 3 | 2 | - | 3 | 2 | - |
| Usnea sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Bryophytes | 4 | 6 | 3 | 2 | 3 | 1 | 3 | 1 | 4 | 4 | 4 | - | 3 | 3 | 2 | 4 | 4 | 4 | 4 | 5 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

important component of the community and may account for up to 80% of the total cover. Leptotheca gaudichaudiana is usually the dominant species. In several cases, bryophytes were apparently dying ahead of the encroaching margins of Conotremopsis thalli.

The community also contains small, often moribund thalli of lichens from wet aspects, e.g. Sphaerophorus insignis, as well as lichens from dry aspects, e.g. Sagenidium and Lecanactis. It develops from the Sphaerophorus ramulifer - S. tener community (4) as the bark ages, trunk girth increases and wet/dry aspects develop. Thus remnants from that community (S. ramulifer - S. tener) are frequently present as well. The dryness of the habitat, a feature shared with more exposed, better lit sites, possibly explains the presence (rarely) of small thalli of canopy species such as Parmelia cunninghamii and Usnea sp.

The Conotremopsis weberiana community is virtually restricted to the study area and to similar rainforests around the northern and western edge of the Central Plateau. Conotremopsis itself extends beyond this region but only in a very depauperate form. Micarea mutabilis has only been recorded in the study area although it may well have been overlooked elsewhere. Similar habitats in other rainforests are usually occupied by related communities dominated by Micarea prasina aggr. or Bactrospora spp. As in the case of community 1, all these communities are restricted mainly to forests containing mature, rough-barked trees which display wet/dry zonation.

(3) Sphaerophorus insignis community (Table 15)

The Sphaerophorus insignis community forms the climax vegetation on the moist aspects of mature trees. It occurs most commonly on Nothofagus cunninghamii where the inclined habit, rough fissured bark and dense bryophyte cover result in one trunk face (the upper one) being very wet.

Character species of the community include Sphaerophorus insignis and Cladia aggregata. Other lichens commonly present are Sphaerophorus tener and S. ramulifer. All these species are fruticose and either scramble over the dense bryophyte mat or project through it in tufts. The bark surface is usually soft and half-rotten and extensive bare patches between the bryophytes and fruticose lichens are rare. Character species adapted to such bare bark include Phyllopsora congregans, Pertusaria sp.1, Psoroma asperellum, P.

Table 15. *Sphaerophorus insignis* community.

| SPECIES | STANDS * | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 13 | 19 | 63 | 76 | 78 | 79 | 84 | 103 | 123 | 143 | 155 | 187 | 189 | 191 | 220 |
| Cladia aggregata | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 1 | - | 1 | 2 | - | 1 | 2 |
| Cladonia chlorophaea | - | 2 | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| C. ochrochlora | - | - | 2 | 1 | - | - | 2 | 2 | 1 | 2 | 1 | - | - | - | - | - | - |
| Dendriscocaulon dendriothamnodes | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| Leioderma amphibolum | 2 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 2 | 1 | - |
| Lepraria incana | - | 1 | - | 2 | - | - | 1 | - | - | - | - | - | - | 1 | - | - | - |
| Leptogium limbatum | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Micarea mutabilis | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pertusaria sp. 1 | - | - | - | - | - | - | - | 1 | 2 | - | - | - | 1 | - | - | - | - |
| Phyllopsora congregans | 2 | - | 2 | 2 | - | 1 | - | 1 | 2 | - | - | - | - | - | - | 3 | 2 |
| Pseudocyphellaria crocata | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 2 | - | - | - |
| P. delisea | 2 | 2 | 2 | 3 | 2 | 2 | - | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 |
| Psoroma asperellum | 1 | 1 | 1 | - | 1 | - | - | 2 | - | - | - | 3 | 3 | - | - | 2 | 1 |
| P. durietzii | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| P. microphyllizans | - | - | - | - | 1 | - | - | - | - | - | - | 2 | 2 | - | 3 | - | - |
| P. paleaceum | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 1 | 2 | 2 | - |
| **Sphaerophorus insignis** | **4** | **4** | **3** | **4** | **3** | **3** | **3** | **4** | **4** | **4** | **3** | **3** | **2** | **3** | **2** | **5** | **3** |
| S. melanocarpus | - | - | 2 | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - |
| S. patagonicus | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - |
| S. ramulifer | - | 2 | 2 | - | 2 | 2 | 1 | 2 | - | 2 | 1 | - | - | 2 | 2 | 2 | 3 |
| S. tener | 2 | 3 | 3 | 4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 2 | 2 |
| Sticta stipitata | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - |
| Thelotrema lepadinum | 2 | 2 | 2 | 1 | - | - | 1 | - | 2 | - | 2 | - | - | 2 | 2 | - | 1 |
| T. subdenticulatum | - | 1 | - | - | 1 | - | - | - | 1 | - | 1 | 2 | - | - | 3 | 1 | 1 |
| Bryophytes | 5 | 5 | 6 | 3 | 4 | 3 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 3 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

paleaceum and Thelotrema subdenticulatum. The last two species can also occur over bryophytes. Pseudocyphellaria delisea and Psoroma microphyllizans are common in the community but are secondary colonisations over bryophytes rather than being attached directly to bark as in pioneer communities or communities on smooth bark. "Primary" individuals have been previously eliminated by decortication or competition with bryophytes and it has been necessary for the species to reinvade the site. Other lichens present include Thelotrema lepadinum which is usually in poor condition and confined to easily dislodged fragments of bark. Lepraria incana is limited to small spots over bryophytes rather than occurring in large coalescing patches as it does on drier aspects. Bryophytes typically contribute the greatest cover to this community and the dominant species include Plagiochila spp. Together with the lichens, they produce a lush greenness which contrasts sharply with the bareness of the Lecanactis - Sagenidium community that usually inhabits the opposite, underhanging face of the tree.

The community develops from the Sphaerophorus ramulifer - S. tener community (4) as the bark ages, fissures, becomes increasingly colonised by bryophytes and hence becomes moister. However, on more upright or smoother trunks where surface moisture presumably drains away more quickly, intermediate forms between these two communities may persist. Near the forest floor, the S. insignis community often intergrades with buttress or forest floor vegetation containing Pseudocyphellaria dissimilis or Peltigera dolichorhiza (see community 5). In extreme shade or on very old trees, it may attain a "post climax" form in which the diversity and cover of lichens is decreased in favour of bryophytes.

The Sphaerophorus insignis community occurs in all rainforest types throughout Tasmania, although it can vary greatly in its constituent species. Despite being found almost exclusively on Nothofagus in the study area, elsewhere in rainforest the community is far less host-specific. In shadier, wetter forests, it contains a greater diversity and cover of bryophytes, particularly such leafy hepatics as Bazzania adnexa, and Sphaerophorus melanocarpus is often dominant or co-dominant. In these cases, the community has usually developed from the Pseudocyphellaria subvariabilis community (7). Further local variations of the community may contain Sphaerophorus macrocarpus, S. murrayi or S. patagonicus whilst in implicate

rainforest, the dominant species is usually S. scrobiculatus. Other common species which can occur between the fruticose lichens and bryophytes include "Asteristion" lamelliferum and Psoroma sp.2.

An additional, related community which also occurs on the lower parts of moist, old trunks is known from outside the study area. This community consists mainly of bryophytes and Pilophorus conglomeratus and is widespread in shady, lowland rainforests.

Communities 1-3 are analogous to the vegetation described under Group 1 in part IIIB.

(4) Sphaerophorus ramulifer-S. tener community (Table 16)

This community is recognised by the very lush development of its dominant species, Sphaerophorus ramulifer, S. tener and Pseudocyphellaria delisea. These lichens can attain covers in excess of 50% of the total stand and occur over bryophytes or directly on bark. Bryophytes are common and provide a substrate for additional species such as Cladonia ochrochlora. Juvenile stages of the community are usually dominated by Pseudocyphellaria delisea and contain a high cover of Psoroma microphyllizans.

The community is found on all tree species in the study area. On Nothofagus, it is often a transitional stage in the development of either "wet" or "dry" climax communities. Thus juvenile thalli of Sphaerophorus insignis, S. melanocarpus, Phyllopsora congregans, Conotremopsis weberiana, Micarea mutabilis and other species characteristic of those communities are often present and indicate the future direction of succession. On vertical trees where aspect differentiation does not occur, succession can be arrested at the Sphaerophorus ramulifer - S. tener community. Lichens from the climax communities (nos. 1-3) may still be present but do not develop fully, and species from "wet" and "dry" aspects can co-occur in the one stand. Similar examples of an "arrested climax" are found on those trunks of Atherosperma or Telopea where conditions are unsuitable (usually too dry) for the development of the climax communities of smooth bark dominated by Pseudocyphellaria billardieri or P. subvariabilis (see nos. 6 and 7). Such stands are usually dominated by P. delisea and Psoroma microphyllizans but the species of Sphaerophorus are also present and well-developed.

The S. ramulifer - S. tener community develops either directly from the Opegrapha stellata - Coccotrema cucurbitula pioneer

Table 16. Sphaerophorus ramulifer - S. tener community.

| SPECIES | STANDS* | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 10 | 16 | 32 | 34 | 90 | 109 | 119 | 131 | 138 | 145 | 149 | 151 | 200 | 206 | 310 | 311 | 312 | 313 | 314 | 315 | 317 | 318 | 319 | 320 |
| Arthothelium sp. 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | 2 | 2 |
| Austroblastenia pauciseptata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | - | - | 2 |
| Catillaria sp. 3 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Catinaria pulverea | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 3 | 2 | - |
| Cladia aggregata | - | 1 | 2 | 3 | - | - | 2 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cladonia chlorophaea | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| C. ochrochlora | 2 | 2 | 2 | 1 | 2 | 2 | 2 | - | - | 2 | - | - | 1 | 2 | 1 | - | - | 2 | 2 | - | - | - | 1 | - | - |
| Coccotrema cucurbitula | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 | - | - | - | 2 | - | - | - | - | - | - | - | - |
| Conotremopsis weberiana | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 | 2 | - | - | 1 | - | - |
| Hypogymnia turgidula | 1 | - | - | - | - | - | 2 | - | 1 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Leioderma amphibolum | - | 1 | - | - | 1 | 2 | - | - | - | - | - | - | 1 | 1 | 1 | - | - | - | - | - | - | - | - | - | - |
| Lepraria incana | 2 | - | 2 | 2 | - | - | 1 | 1 | - | - | - | - | 1 | 1 | 2 | - | - | 1 | - | 2 | - | - | - | - | 2 |
| Menegazzia globulifera | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. weindorferi | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - |
| Micarea mutabilis | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | 2 | - | - | 2 | 2 | - | - |
| M. prasina aggr. | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| Opegrapha stellata | - | - | - | - | - | 1 | - | 2 | - | - | - | 1 | - | - | - | 2 | 2 | - | - | 2 | - | - | - | - | 2 |
| Parmelia cunninghamii | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| P. testacea | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | - | - | 1 | - | 1 | - | - | 1 | - | 2 | - | - |
| Parmeliella nigrocincta | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 2 | - |
| Pertusaria nothofagi | - | - | - | - | 1 | - | - | - | - | 1 | 1 | - | - | - | 1 | - | - | - | 1 | 2 | - | - | - | - | - |
| Phlyctella subuncinata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Phyllopsora congregans | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| Pseudocyphellaria delisea | 3 | 2 | 2 | 4 | 4 | 3 | - | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 |
| Psoroma asperellum | 1 | - | - | 3 | - | 1 | - | - | - | - | 2 | - | - | - | - | - | - | - | 2 | - | - | - | 1 | 2 | - |
| P. durietzii | - | - | - | - | - | - | - | - | 1 | 2 | 1 | - | - | 1 | - | - | 1 | - | - | 2 | - | - | - | - | - |
| P. microphyllizans | - | - | - | 3 | 3 | 2 | - | - | 2 | - | 2 | 2 | - | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | - | 3 | 2 |
| Ramonia muscicola | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Sphaerophorus insignis | - | - | 2 | - | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | - | 2 | 1 | - | - | - | 1 | 1 | - | - | - | - | - |
| S. melanocarpus | - | 2 | - | - | - | - | - | - | - | - | 2 | - | - | 2 | - | - | - | - | 1 | - | - | - | - | - | - |
| **S. ramulifer** | **3** | **3** | **2** | - | - | - | **4** | **2** | **5** | **3** | **3** | **2** | **3** | **3** | **3** | **2** | - | **3** | **4** | **2** | **2** | **3** | **2** | - | **2** |
| **S. tener** | **4** | **4** | **4** | **2** | **3** | **3** | **3** | **3** | **3** | **5** | **4** | **3** | **4** | **3** | **4** | **3** | **3** | **4** | **4** | **2** | **3** | **5** | **3** | **3** | **3** |
| Sticta stipitata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - |
| Thelotrema lepadinum | 2 | 2 | 2 | - | - | 3 | - | 3 | 2 | - | 2 | 1 | 2 | 2 | 2 | 2 | 4 | - | 1 | 3 | 3 | 2 | 3 | 2 | 4 |
| T. subdenticulatum | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Usnea sp. | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | - | - | - | 1 | 1 | 1 | - | - |
| Bryophytes | 4 | 4 | 4 | 5 | 5 | 5 | 4 | 3 | 1 | 3 | 2 | 2 | 1 | 4 | 2 | 4 | 3 | 3 | 4 | 3 | 3 | 2 | 4 | 5 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

community (10) or from the Parmelia testacea - Pertusaria nothofagi community (9) as the substrate ages or becomes shaded. These mixed origins are reflected in the diverse range of remnant lichens which may be present from these communities, e.g. Parmelia testacea, Coccotrema cucurbitula, Opegrapha stellata, Pertusaria nothofagi and Thelotrema lepadinum.

Outside the study area, this community is common in high altitude rainforests but is less conspicuous in lowland forests where conditions are usually too wet and shaded and the success of bryophytes often precludes a lush development of macrolichens. However, similar lichen vegetation occurs higher up on tree trunks in lowland forests and Group 2 from part IIIB is referable to this community.

The generally central or intermediate position of this community in the successional scheme of epiphytic vegetation (Fig. 12) makes it a potentially variable and floristically diverse grouping. It lacks any faithful character species and is based almost entirely on the maximum development of several common, wide-ranging lichens, e.g. Sphaerophorus ramulifer, S. tener and Pseudocyphellaria delisea. These species can be ascribed to fidelity class III [after Shimwell (1970) p.210] although the absence of truly faithful species (of class I) means that the community does not fulfil the requirements for a distinct association in the strict classical sense (cf. Mueller-Dombois and Ellenberg 1974). Nevertheless, the S. ramulifer - S. tener community as described above is so common in the study area that it deserves separate treatment in order to describe adequately the flora of the site.

(5) Pseudocyphellaria dissimilis - Peltigera dolichorhiza community (Table 17)

This community occurs on the buttresses of old trees and on the forest floor over rocks, rotting wood and peat. It is rare in the study area and is confined to the shadiest, wettest sites, usually along the river bank.

The community is composed mainly of lichens with a blue-green photobiont or with cephalodia. It is characterised chiefly by Pseudocyphellaria dissimilis and Peltigera dolichorhiza, either of which may occur in pure stands of up to 1 sq. m in extent. Sticta stipitata is very abundant and frequently occurs in photosymbiodemes

Table 17. *Pseudocyphellaria dissimilis* - *Peltigera dolichorhiza* community.

| SPECIES | STANDS * | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 21 | 136 | 188 | 241 | 244 | 246 | 248 | 250 | 251 | 255 | 256 | 257 |
| Bacidia buchananii | - | - | - | - | - | - | 2 | 2 | - | - | - | - |
| Cladia aggregata | - | - | - | - | - | - | - | - | - | 2 | 2 | 3 |
| Cladonia scabriuscula | - | - | - | - | - | - | - | - | 1 | 2 | 2 | 2 |
| Dendriscocaulon dendriothamnodes | 2 | - | - | - | - | - | 2 | - | 2 | - | - | - |
| Lepraria incana | - | - | - | - | 1 | - | - | - | - | - | - | - |
| Leptogium limbatum | - | - | 1 | - | - | - | 2 | 1 | 3 | - | 3 | - |
| L. victorianum | - | - | - | 3 | - | - | 2 | - | - | - | - | - |
| Parmeliella nigrocincta | 2 | - | - | - | - | - | 2 | - | - | - | - | - |
| **Peltigera dolichorhiza** | **3** | **2** | **-** | **-** | **1** | **2** | **-** | **-** | **3** | **1** | **2** | **2** |
| Placopsis gelida | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Pseudocyphellaria billardieri | - | 2 | 3 | - | - | - | - | - | - | - | 1 | - |
| P. crocata | - | - | - | - | - | - | - | - | 3 | - | - | - |
| P. delisea | - | 4 | - | 2 | - | - | 2 | - | 2 | 2 | 3 | - |
| **P. dissimilis** | **4** | **3** | **3** | **5** | **5** | **6** | **4** | **5** | **1** | **-** | **-** | **3** |
| P. subvariabilis | - | - | - | - | 1 | - | 2 | 2 | - | 4 | - | 3 |
| Psoroma microphyllizans | 2 | - | 3 | 2 | 3 | 1 | 3 | 2 | 2 | - | - | - |
| Sphaerophorus tener | 2 | 3 | - | - | - | - | - | 1 | - | 2 | 3 | - |
| Stereocaulon ramulosum | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Sticta stipitata | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | - | - | - |
| Thelotrema lepadinum | - | - | 1 | - | - | - | - | - | - | - | - | - |
| T. subdenticulatum | - | - | 2 | - | - | - | - | - | - | - | - | - |
| Bryophytes | 5 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

with Dendriscocaulon dendriothamnodes. Less common character species of this community include Leptogium limbatum, L. victorianum and Bacidia buchananii. Pseudocyphellaria delisea and Psoroma microphyllizans occur over bryophytes and are rarely found attached directly to the bark, wood or rock substrate. In general, crustose lichens are absent from the community but bryophytes are common and diverse. The ferns, Grammitis billardieri and Hymenophyllum peltatum, and the small herbs, Uncinia tenella (Cyperaceae) and Lagenophora stipitata (Compositae) are sometimes present.

When epiphytic, this community is found mainly on Nothofagus which provides the best examples of broad, spreading buttresses and thick exposed roots. With increasing height on such trees, it usually grades into the Sphaerophorus insignis community. Alternatively it may grade into the Pseudocyphellaria subvariabilis - Psoroma microphyllizans community (7), particularly on phorophytes with smooth bark. At the ground, the Pseudocyphellaria dissimilis community may intergrade with obligate forest floor communities (see p.158) which contain Stereocaulon ramulosum, Placopsis gelida or Cladonia scabriuscula.

The Pseudoyphellaria dissimilis - Peltigera dolichorhiza community is widespread in those lowland rainforests with moist, shady understoreys, open ground and such specialised habitats as large logs or trees with spreading buttreses and exposed roots (i.e. most callindendrous and thamnic forests). In such forests, it also occurs on Dicksonia antarctica trunks and, in extremely shaded situations, may extend up to 2 m on trees and shrubs. However, in more open rainforest or at high altitudes such as in the study area, it becomes extremely basal and often poorly developed. Other lichens which may be present in the community across its entire range include Collema subconveniens, Dictyonema sericeum, Pseudocyphellaria cf. insculpta and P. subvariabilis.

(6) Pseudocyphellaria subvariabilis - Psoroma microphyllizans community (Table 18)

This community is essentially a shade tolerant facies of the Pseudocyphellaria billardieri - Psoroma microphyllizans community (7). The main floristic difference between the two communities lies in the replacement of P. billardieri by P. subvariabilis. In addition, the diversity of lichens is noticeably lower in the P.

Table 18. Pseudocyphellaria subvariabilis - Psoroma microphyllizans community.

| SPECIES | STANDS * | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 118 | 134 | 190 | 203 | 204 | 231 | 242 | 243 | 245 | 247 | 259 |
| Cladia aggregata | 2 | - | 1 | - | 1 | - | - | - | - | - | 2 |
| Cladonia chlorophaea | - | - | - | - | 1 | - | - | - | - | - | - |
| C. ochrochlora | - | 1 | 1 | - | - | - | - | - | - | - | - |
| Coccotrema cucurbitula | - | - | - | - | - | - | - | - | - | - | 1 |
| Dimerella lutea | - | - | - | - | - | - | - | - | - | 2 | - |
| Lepraria incana | - | - | - | - | 1 | 1 | - | 1 | - | - | - |
| Nephroma australe | - | - | - | - | - | - | - | - | - | 2 | - |
| Parmelia tenuirima | - | - | - | - | - | - | - | - | - | 1 | - |
| Pseudocyphellaria argyracea | - | 1 | - | - | - | - | - | - | - | - | - |
| P. billardieri | - | - | - | - | - | - | - | - | - | - | 1 |
| P. delisea | 2 | 2 | 2 | 2 | 3 | - | - | 2 | 2 | 2 | 2 |
| P. dissimilis | 2 | - | 2 | - | - | - | - | - | 1 | - | - |
| **P. subvariabilis** | **3** | **3** | **4** | **6** | **3** | **5** | **5** | **3** | **5** | **2** | **4** |
| Psoroma asperellum | - | - | 2 | - | - | - | - | 2 | - | - | 1 |
| P. durietzii | - | 1 | - | - | - | - | - | - | - | - | - |
| **P. microphyllizans** | **2** | **2** | **3** | - | - | **2** | **4** | **2** | **2** | **3** | **1** |
| P. paleaceum | - | - | - | - | - | - | - | - | - | - | 2 |
| Psoromidium aleuroides | - | - | - | - | - | - | - | - | - | 2 | - |
| Sphaerophorus insignis | 1 | 2 | 3 | 3 | 2 | - | - | - | 3 | - | - |
| S. melanocarpus | - | 3 | - | - | 3 | - | - | - | - | - | 1 |
| S. patagonicus | - | - | 3 | - | - | - | - | - | - | - | - |
| S. ramulifer | - | - | 2 | - | 3 | - | - | - | - | - | - |
| S. tener | - | 2 | 2 | - | 3 | - | 1 | - | - | - | 2 |
| Sticta stipitata | 2 | 2 | 2 | - | - | - | 1 | 2 | 3 | 2 | - |
| Thelotrema lepadinum | - | - | 1 | 2 | - | 1 | 2 | 1 | - | 2 | - |
| T. subdenticulatum | - | - | 1 | - | - | - | - | - | - | - | - |
| Bryophytes | 5 | 4 | 3 | 3 | 4 | 3 | 2 | 3 | 3 | 2 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

subvariabilis community and, apart from Psoroma microphyllizans, Sticta stipitata and Pseudocyphellaria subvariabilis itself, most other species are relatively poorly developed. However, bryophytes are very prolific and the fern, Grammitis billardieri, is often present. Nevertheless, the two communities are superficially similar in their high covers of bright green macrolichens and in the very poor representation of crustose lichens.

Although P. subvariabilis is quite common in the study area, it occurs mainly as a saxicolous or terricolous species in forest floor or buttress communities (e.g. no.5). In contrast, the P. subvarabilis - Psoroma microphyllizans community is rare and is restricted to moist shady groves or to the large exposed roots of river-bank trees. In such habitats, it intergrades with the Pseudocyphellaria dissimilis - Peltigera community or with the Sphaerophorus insignis community. Consequently, S. insignis itself is commonly present in the community or is replaced by S. melanocarpus which tends to favour moister, shadier habitats.

The Pseudocyphellaria subvariabilis - Psoroma microphyllizans community comprises the dominant basal, epiphytic vegetation in virtually all lowland rainforest types. It occurs on young stems, branches and mature trunks of most tree species, particularly those with smooth bark, and is one of the epiphytic communities which conveys the impression of green lushness in Tasmanian rainforests. However, in high altitude callidendrous forests (such as the study area), the climate is apparently too dry or exposed. Thus the community is effectively "pushed" downwards and, apart from locally wet or shaded sites, is displaced from the bottom of tree trunks by other communities, e.g. its P. billardieri facies or the Sphaerophorus ramulifer - S. tener community (see also p.68).

Additional species sometimes common in stands outside the study area include Collema subconveniens, Parmeliella nigrocincta and "Asteristion" lamelliferum. Pseudocyphellaria delisea often contributes a high cover to the community. The vegetation described under groups 3-4 in part IIIB can be referred to the P. subvariabilis - Psoroma microphyllizans community.

(7) Pseudocyphellaria billardieri - Psoroma microphyllizans community (Table 19).

The Pseudocyphellaria billardieri - Psoroma microphyllizans community occurs mostly on smooth bark under humid, moderately shaded conditions. In the study area, it is best developed near the base of the waterfall where the forest canopy is broken but humidity is maintained by clouds of spray. Elsewhere it is mainly confined to trees along the river-bank or drainage channels. Although the community is not host-specific, occurring on trunks and branches of various trees, it is most common on Atherosperma and Telopea which retain smooth bark into maturity. However, some of the best examples of the community are found on dead Nothofagus or on Nothofagus in the spray zone of the waterfall where the process of decortication appears to have been arrested.

The community consists almost entirely of large, bright green foliose or squamulose lichens. Its character species include Pseudocyphellaria billardieri, Psoromidium aleuroides and Parmeliella nigrocincta. Psoroma microphyllizans, which occurs in several other communities as well, attains the peak of its development here and may constitute up to 80% of the total cover of the stand. Sticta stipitata is also very common. In contrast, crustose species are depauperate and mainly include remnants of pioneer species such as Thelotrema lepadinum, Coccotrema cucurbitula and Phlyctella subuncinata which are soon overgrown by the more aggressive macrolichens. Bryophytes are also relatively poorly developed.

The community represents the next stage in succession on smooth bark from the pioneer Opegrapha stellata - Coccotrema cucurbitula community (10). However, away from its optimum habitat, the development of its characteristic macrolichens is retarded and the pioneer species are more persistent. Under deteriorating conditions, Parmeliella nigrocincta, Sticta stipitata, Psoromidium aleuroides and, eventually, Pseudocyphellaria billardieri are replaced by more wide-ranging species such as P. delisea and Sphaerophorus tener. Thus the community intergrades with the S. ramulifer - S. tener community. A similar transition can occur as the bark of the phorophyte ages and fissures. Alternatively, the vegetation may grade into the Pseudocyphellaria rubella - P. faveolata community (8), particularly on low branches where Nephroma australe is often present. In extreme

Table 19. Pseudocyphellaria billardieri - Psoroma microphyllizans community.

| SPECIES | STANDS* | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 125 | 139 | 144 | 168 | 169 | 182 | 230 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 249 |
| Arthothelium sp. 1 | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| Bacidia weymouthii | - | - | - | 2 | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Catinaria sp. | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| C. pulverea | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Chiodecton colensoi | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Cladonia ochrochlora | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Coccotrema cucurbitula | - | 2 | - | 3 | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Coenogonium implexum | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Collema laeve | - | - | - | - | - | - | - | - | - | - | 2 | - | 1 | 1 | - | - | - |
| Dimerella lutea | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| Leioderma amphibolum | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Lepraria incana | 1 | - | - | - | - | - | - | 1 | - | - | - | 2 | - | - | - | - | - |
| Nephroma australe | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Opegrapha stellata | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | 2 | - |
| Parmelia tenuirima | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| Parmeliella nigrocincta | - | - | 2 | - | - | - | - | - | - | - | 2 | 2 | 3 | 2 | 2 | - | - |
| Pertusaria nothofagi | - | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Phlyctella subuncinata | - | - | - | - | - | - | - | - | - | - | 1 | - | 2 | - | - | - | 3 |
| Pseudocyphellaria argyracea | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **P. billardieri** | **2** | **3** | **3** | **5** | **3** | **2** | **4** | **3** | **3** | **3** | **2** | **3** | **2** | - | **2** | **3** | **3** |
| P. crocata | - | - | - | - | - | - | - | - | - | 1 | - | - | 1 | 1 | - | - | - |
| P. delisea | 1 | 2 | 2 | - | 3 | 2 | 2 | 1 | 2 | 2 | - | - | 1 | 2 | 2 | 2 | 2 |
| P. subvariabilis | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| Psoroma asperellum | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **P. microphyllizans** | **5** | **3** | **2** | **2** | **2** | **3** | **4** | **3** | **5** | **4** | **4** | **6** | **3** | **4** | **2** | **3** | **2** |
| P. paleaceum | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| P. pholidotoides | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 4 | - | - |
| Psoromidium aleuroides | - | - | - | - | - | - | - | - | - | - | 4 | - | 3 | 2 | 2 | - | - |
| Sphaerophorus insignis | 2 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| S. tener | 1 | 3 | 3 | - | - | - | - | 2 | - | - | - | 1 | - | - | - | 1 | 1 |
| Sticta stipitata | - | - | - | - | 2 | - | - | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | - | - |
| Thelotrema lepadinum | 2 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 2 | - | 1 | - | 2 | 2 | 2 | 2 | 3 |
| Bryophytes | 1 | 3 | 4 | - | - | 5 | 3 | 5 | 3 | 2 | 2 | 2 | - | 2 | 2 | 2 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

shade and moisture, it merges with the Pseudocyphellaria subvariabilis community (6).

The Pseudocyphellaria billardieri - Psoroma microphyllizans community is widespread in most callidendrous and thamnic rainforests in Tasmania, as well as in some wet sclerophyll forests. However, it is easily overlooked when it occurs in the middle height zones of the forest (see Group 6 in part IIIB). Excellent examples can be found on Olearia argophylla whose spreading branches with persistent, fibrous bark provide an ideal substrate. In some thamnic forests with open understoreys, the community predominates on the young branches of Anodopetalum or Trochocarpa gunnii. Additional lichens sometimes present in the community include Psoroma pholidotoides, P. soccatum, Collema laeve and C. leucocarpum.

(8) Pseudocyphellaria rubella - P. faveolata community

(Table 20)

This community is one of the most luxuriant epiphytic rainforest communities. Its character species include the large foliose lichens, Pseudocyphellaria rubella, P. faveolata and Nephroma australe, which may all form thalli up to 20 cm diameter, completely covering the substrate and projecting beyond it. Other, more appressed character species include Psoroma durietzii and P. leprolomum. Pseudocyphellaria billardieri and Sphaerophorus tener are also common, the latter forming lush festoons amongst the foliose lichens. The growth of these species is apparently very fast and they often overgrow each other. Their growth rate seems to exceed their ability to support themselves and the ground below is often littered with fallen thalli. However, regeneration is rapid for rarely is any uncolonised bark apparent.

The community is potentially very rich in species and additional lichens sometimes present include Menegazzia ultralucens, Pseudocyphellaria colensoi and Psoromidium versicolor. Crustose species are relatively rare and consist of remnants from previous stages of succession. The development of bryophytes is variable but their total cover rarely exceeds 25%. Leptostomum inclinans and Radula sp. are usually dominant and can provide secondary substrates for lichens.

This community is very localised in the study area and is mostly confined to a single boggy site, infilled with Sphagnum to the

Table 20. Pseudocyphellaria rubella - P. faveolata community.

| SPECIES | STANDS* | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 252 | 258 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 |
| Austroblastenia pauciseptata | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bacidia weymouthii | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Cladonia ochrochlora | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 1 |
| Coccotrema cucurbitula | - | 2 | - | 3 | - | - | - | - | 2 | - | 3 | - | 3 | - |
| Dendriscocaulon dendriothamnodes | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - |
| Hypogymnia turgidula | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| Leioderma amphibolum | - | - | 2 | - | - | 1 | - | - | - | - | - | - | - | - |
| Lepraria incana | 1 | - | 2 | - | - | - | - | - | - | 1 | - | - | - | - |
| Megaloblastenia marginiflexa | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Menegazzia globulifera | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| M. ultralucens | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| M. weindorferi | - | - | - | - | - | - | 1 | - | 1 | - | 2 | - | 2 | 2 |
| Nephroma australe | 2 | 2 | - | 3 | 3 | 2 | 2 | 2 | - | - | 2 | - | 3 | - |
| Opegrapha stellata | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| Parmelia cunninghamii | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| P. tenuirima | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | - |
| P. testacea | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Pertusaria nothofagi | - | - | 3 | - | - | - | - | - | 2 | - | - | - | - | 2 |
| Phlyctella subuncinata | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| Pseudocyphellaria billardieri | 3 | 3 | 3 | 2 | 2 | 4 | - | 4 | - | 4 | 2 | 3 | 2 | 2 |
| P. colensoi | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| P. crocata | - | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - |
| P. delisea | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| **P. faveolata** | - | **3** | **3** | **2** | **3** | - | **5** | **4** | - | **3** | **1** | **4** | **2** | - |
| **P. rubella** | - | **1** | **3** | **2** | **3** | **3** | - | - | **4** | - | **3** | **3** | **4** | **4** |
| Psoroma asperellum | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| P. durietzii | - | - | 2 | - | - | 2 | 2 | - | 1 | - | 1 | 2 | 2 | - |
| P. leprolomum | - | - | 2 | 2 | - | 2 | - | 2 | - | 3 | - | - | - | - |
| P. microphyllizans | 3 | 3 | 2 | - | 2 | - | - | - | - | - | - | - | - | 1 |
| P. paleaceum | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Psoromidium versicolor | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sphaerophorus ramulifer | - | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - |
| S. tener | 2 | 2 | 2 | - | 1 | 2 | 3 | - | - | 1 | 2 | 2 | 2 | 4 |
| Sticta stipitata | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Thelotrema lepadinum | - | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - |
| Usnea sp. | - | - | - | - | - | - | 1 | - | - | - | 2 | - | 2 | 2 |
| Bryophytes | 2 | 2 | 3 | - | 1 | - | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

depth of over 1 m. The forest canopy above is broken and the mossy bog supports an array of misshapen trees or shrubs of Tasmannia, Nothofagus, Cyathodes juniperina and Leptospermum lanigerum, mostly about 2 m tall. The lichen community inhabits these small diameter trunks, twigs and branches of these species, as well as those branches of surrounding tall trees which project into the clearing. Away from this site, poorly developed examples of the community were observed only along the river bank. These environmental conditions are interpreted as being well-lit but very humid, mainly due to the Sphagnum mounds which act as a continuous store of moisturite is also protected from drying air currents and long periods of direct sunlight by the surrounding tall trees and their crowns which partly overhang the bog.

The Pseudocyphellaria rubella - P. faveolata community develops from the Opegrapha stellata - Coccotrema cucurbitula pioneer community (10) as the substrate ages in the specific climatic requirements of high light and high humidity. Away from these habitat conditions, it is usually replaced by the Pseudocyphellaria billardieri - Psoroma microphyllizans community on smooth bark or the Sphaerophorus ramulifer - S. tener community on rough bark. Stands intermediate with these communities as well as with the Parmelia testacea - Pertusaria nothofagi community have been observed.

The Pseudocyphellaria rubella - P. faveolata community is widespread in Tasmanian rainforests where it is usually confined to upper height zones, in the subcanopy or in the crowns of subdominant trees. Additional species often present include Nephroma cellulosum, Lecidea ceroplasta, Pseudocyphellaria ardesiaca, P. colensoi, P. coronata, Menegazzia nothofagi and species of Psoroma and Collema. Further sampling in other rainforest sites may enable separate communities to be recognised in this diverse assemblage. Groups 5,7, and 8 in part IIIB are at least partly referable to this community.

(9) Parmelia testacea - Pertusaria nothofagi community

(Table 21)

The Parmelia testacea - Pertusaria nothofagi community occurs on smooth bark in open, well-lit conditions. Its most typical habitat is on the middle to upper regions of mature trees and on the main branches of the canopy. It is best developed on Nothofagus. However, in several places in the study area where the trees are younger,

lower, straight and more or less even-aged, and the canopy is broken by dead eucalypts, the community extends down the trunk to inhabit virtually the entire height of the tree. Elsewhere in the study area it was recorded mainly on young limbs or trunks in clearings or on fallen limbs.

The most common character species include Parmelia testacea, P. tenuirima, P. cunninghamii, Menegazzia weindorferi and Pertusaria nothofagi. The last species may contribute over 50% of the total cover of the community. Usnea sp. and Hypogymnia turgidula are also common, particularly on younger substrates. All these species together convey a bright grey-white colour to the epiphytic vegetation which contrasts sharply with the lush greenness of most other trunk communities.

Remnant thalli of species from earlier stages in succession are usually present. These include species from either the Pannoparmelia angustata community (11) or the Opegrapha stellata - Coccotrema cucurbitula community (10), e.g. Catinaria sp., Coccotrema cucurbitula, Parmelia labrosa, P. subglabra and Thelotrema lepadinum. However, most of the pioneer crustose species are rapidly overgrowm by Pertusaria nothofagi. Bryophytes are sparse on young branches but increase in abundance on trunks. The dominant species are typically Leptostomum inclinans which forms thick pads and Radula sp. which forms scrambling mats. Both provide substrates for additional lichens such as Cladonia ochrochlora which occurs on Leptostomum, and Leioderma amphibolum which is often associated with Radula.

Aging of the substrate generally leads to increased shade as the young limbs and trunks develop denser, more extensive foliage. The community is then invaded by shade-tolerant species such as Pseudocyphellaria delisea, Psoroma microphyllizans and Sphaerophorus tener which establish near the base of the young tree or limb and gradually spread upwards. As the bark begins to fissure, a gradual transition towards the Sphaerophorus ramulifer - S. tener community occurs. Micro-habitat differences on the trunk also become apparent with age and even slightly sheltered underhangs may be colonised by Lepraria incana or other "dry" species such as Conotremopsis. Intergradation with the Pseudocyphellaria rubella - P. faveolata community can also occur.

The Parmelia testacea - Pertusaria nothofagi community is found in virtually all rainforest vegetation. In mature lowland forests, it

Table 21. Parmelia testacea - Pertusaria nothofagi community.

| SPECIES | STANDS * | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7 | 23 | 25 | 26 | 28 | 29 | 31 | 36 | 40 | 44 | 47 | 64 | 66 | 68 | 71 | 73 | 85 | 98 | 101 | 280 |
| Catillaria sp. 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Catinaria sp. | - | - | - | - | - | 3 | 1 | - | - | - | - | - | 1 | - | - | - | 2 | - | - | 2 |
| Cetraria chlorophylla | - | - | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| Cladonia ochrochlora | - | - | - | - | - | - | 2 | 1 | - | 1 | - | - | - | - | - | 2 | - | - | - | - |
| Coccotrema cucurbitula | 2 | - | - | - | - | - | - | - | 2 | - | - | - | - | - | 2 | - | - | - | - | - |
| Hypogymnia lugubris | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| H. mundata | - | - | 2 | - | - | - | - | - | - | - | - | 2 | - | - | 2 | - | - | - | - | - |
| H. turgidula | - | - | 1 | - | 1 | - | 2 | 2 | - | 1 | - | - | - | 2 | 2 | - | 2 | 1 | 2 | - |
| Lecidea sp. 1 | - | - | 2 | - | - | - | - | - | - | - | - | - | - | 2 | - | - | 2 | - | - | - |
| Lecidella elaeochroma | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Leioderma amphibolum | - | 1 | 1 | 1 | 1 | - | 2 | 1 | 1 | 2 | - | 1 | - | 2 | - | - | - | - | - | - |
| Lepraria incana | - | 2 | - | - | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | - | - | - | - | - | - | - | - |
| Menegazzia globulifera | - | - | - | - | - | - | - | - | - | 2 | 1 | - | - | - | - | - | - | - | - | - |
| M. retipora | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 |
| M. weindorferi | 2 | 3 | 2 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 2 |
| Micarea mutabilis | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. prasina aggr. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Mycoblastus sp. 1 | - | - | - | 1 | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | 3 |
| Opegrapha stellata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 3 | - |
| Pannoparmelia angustata | - | - | 2 | - | - | - | - | - | - | - | 1 | - | - | 2 | - | - | - | - | - | - |
| Parmelia cunninghamii | 2 | - | - | - | - | - | - | - | - | - | - | 2 | 2 | - | 2 | - | 3 | 2 | - | - |
| P. labrosa | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - | - |
| P. subglabra | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| P. tenuirima | 2 | - | - | 2 | 2 | 3 | 2 | 2 | 1 | - | - | 2 | 3 | 2 | 4 | 3 | 2 | - | - | 2 |
| **P. testacea** | **3** | **4** | **3** | **3** | **5** | **3** | **3** | **3** | **2** | **3** | **3** | **3** | - | **2** | - | **2** | - | **3** | **3** | - |
| Pertusaria sp. 1 | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| **P. nothofagi** | **4** | **2** | **4** | **3** | **3** | **3** | **3** | **4** | **5** | **3** | **5** | **5** | **4** | **3** | - | **2** | **4** | **3** | **3** | - |
| Pseudocyphellaria delisea | 3 | - | 2 | 1 | 1 | - | 1 | - | 2 | - | 1 | - | - | - | - | 1 | - | - | 3 | 2 |
| Psoroma microphyllizans | - | 2 | 2 | 2 | 2 | 1 | 1 | - | 2 | - | - | - | - | - | - | - | - | - | - | - |
| Rinodina dissa | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - |
| Sphaerophorus tener | 2 | - | - | 2 | - | - | - | - | - | - | 1 | 1 | - | - | 2 | - | - | 5 | 3 | 3 |
| Thelotrema lepadinum | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 2 | - | 2 |
| Usnea sp. | 2 | 1 | - | 1 | - | - | 2 | - | - | 1 | - | 2 | 1 | - | 2 | - | 1 | - | - | 2 |
| U. arida | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - |
| Bryophytes | 2 | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 4 | 5 | 3 | 3 | 1 | 4 | 3 | 3 | 2 | - | 2 | 3 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

is confined to the canopy but at high altitudes or in young forests, it may occur over the entire height of the trees, from the ground upwards. The relative dominance of the species of Hypogymnia, Parmelia or Menegazzia involved varies from site to site, but the basic habitat and structure of the community remains the same and Pertusaria nothofagi is invariably present. For example, at lower altitudes, Parmelia tenuirima or P. cunninghamii are usually dominant. In north-eastern Tasmania, P. revoluta or P. subfatiscens become abundant. Other species which can figure prominently in this community include Hypogymnia lugubris, H. mundata, Parmelia protosulcata and Usnea arida. Where the community extends into subalpine altitudes, Menegazzia bullata, M. globulifera, M. subbullata, M. testacea and Mycoblastus spp. may be present. Groups 9-10 from part IIIB can be referred to this community.

Parmelia testacea is considered in this discussion in the sense of Galloway and Elix (1983) although in the future, the chemical variants of this species are likely to be referred to different taxa (M.E. Hale pers. comm.).

(10) Opegrapha stellata - Coccotrema cucurbitula community (Table 22)

The Opegrapha stellata - Coccotrema cucurbitula community represents the pioneer vegetation of twigs and saplings within the generally more sheltered climate of the forest interior (in contrast to twigs in the canopy). The community is found exclusively on smooth bark and consists almost entirely of crustose lichens. Thus most macrolichens and bryophytes present can be regarded as forerunners of subsequent stages in succession.

Common character species include Opegrapha stellata, Coccotrema cucurbitula, Austroblastenia pauciseptata, Bacidia weymouthii, Phlyctella subuncinata, Catinaria sp., Chiodecton colensoi and species B. Thelotrema lepadinum is also very common but because of its persistence during succession, it occurs through virtually the entire range of epiphytic rainforest vegetation and hence cannot be regarded as a character species. Aspect differentiation is minor. Generally, diversity of lichens is lower on the undersides of the twigs or on the underhanging surfaces of inclined saplings. Here the cover of bryophytes is usually marginally higher and small thalli of Lepraria incana are sometimes present.

The relative dominance and combination of the common species varies considerably from one stand to the next. The community is most diverse in clearings or along the river bank. In these situations, virtually no differences are evident between stands of the community occurring on different hosts, presumably because the habitat is uniformly suitable for all species. However, in the shade or away from the river, diversity decreases, sometimes to the extent that pure stands of a single species, commonly Thelotrema lepadinum or Phlyctella subuncinata, are developed. Under less optimum conditions such as these, some host-preferences also become apparent, suggesting that microhabitat factors which are determined by the phorophyte have become important. For example, Austroblastenia pauciseptata and Catinaria sp. tend to be more common on Telopea or Nothofagus whilst Phlyctella subuncinata, Bacidia weymouthii, Chiodecton colensoi and species B become preferential to Atherosperma. Further work may warrant the recognition of a separate Atherosperma - preferential community characterised by Bacidia weymouthii and Phlyctella subuncinata. However, this segregation has not been adopted in the present study because of the potential intermixing of all the species under certain, apparently ideal, conditions. Furthermore, given the overall complexity of this type of vegetation, a conservative "lumping" approach appears more suitable at this stage. The problem is discussed further on p.167.

In very open habitats, the Opegrapha - Coccotrema community intergrades with the Pannoparmelia angustata community (11). Here Parmelia labrosa and P. subglabra are also present and Pertusaria nothofagi is the dominant crustose lichen. As the substrate ages, such stands will usually develop towards the Parmelia testacea - Pertusaria nothofagi community, a successional pathway indicated by the presence of juvenile thalli of Parmelia testacea, Menagazzia weindorferi or Usnea sp. More commonly, however, the community will develop into either the Sphaerophorus ramulifer - S. tener community, the Pseudocyphellaria rubella - P. faveolata community or the P. billardieri - Psoroma microphyllizans community, depending on the substrate and local micro-climatic conditions. Again, the particular direction of succession is revealed by the presence of juvenile thalli of characteristic macrolichens.

In Tasmanian rainforest in general, the Opegrapha - Coccotrema community described above is just one of several starting points in

Table 22. Opegrapha stellata - Coccotrema cucurbitula community.

| SPECIES | STANDS * | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 177 | 195 | 199 | 212 | 216 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 271 | 272 | 273 | 274 | 276 | 277 | 278 | 279 | 281 | 287 | 316 |
| Arthothelium sp. 1 | - | - | - | 1 | - | - | - | - | - | - | - | 2 | 2 | - | - | 2 | 2 | - | - | - | - | - | - | - | - |
| Austroblastenia pauciseptata | 2 | - | - | - | 2 | - | 1 | 1 | - | 5 | 2 | 2 | 1 | 4 | - | 1 | 2 | - | - | - | 3 | - | - | - | - |
| Bacidia weymouthii | 2 | - | - | - | - | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | - | 1 | 2 | - | 1 | - | 3 | 2 | 3 | 2 | - | 3 |
| Catillaria sp. 1 | - | - | - | - | - | - | - | 1 | 2 | - | - | - | - | 2 | - | - | - | - | 1 | - | - | - | - | 2 | 2 |
| Catinaria sp. | - | - | - | - | 1 | - | - | - | - | 2 | - | 2 | - | - | - | - | - | - | 2 | - | - | - | 2 | - | 3 |
| C. pulverea | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cetraria chlorophylla | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| Chiodecton colensoi | - | - | - | - | - | 2 | 1 | 2 | 2 | 2 | 1 | - | - | - | - | - | - | - | 2 | 3 | 2 | - | - | - | 2 |
| **Coccotrema cucurbitula** | - | **4** | **2** | **3** | **3** | - | - | **2** | **2** | **2** | **3** | **4** | **5** | **3** | - | - | - | **2** | **2** | - | **3** | - | - | **2** | **2** |
| Dimerella lutea | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Haematomma infuscum | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - | 2 |
| Hypogymnia turgidula | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lecidea sp. 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| Lepraria incana | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Megaloblastenia marginiflexa | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | 3 | - | - | 1 | - | - | - | - | - | - |
| Menegazzia nothofagi | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. weindorferi | - | 1 | - | 2 | 2 | - | - | - | - | 2 | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| Ochrolechia sp. | - | - | - | - | - | - | - | - | 1 | - | - | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - |
| **Opegrapha stellata** | - | **4** | **3** | **3** | **3** | **2** | **2** | **2** | **2** | **2** | **4** | **3** | **2** | **3** | **1** | **2** | **3** | **3** | **2** | **2** | **2** | **3** | **1** | **2** | **2** |
| Parmelia cunninghamii | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| P. labrosa | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | 1 | - | - | - | 2 | 2 | 2 |
| P. subglabra | - | - | - | - | - | - | - | - | - | 2 | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 2 | 2 |
| P. tenuirima | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| P. testacea | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pertusaria nothofagi | - | 2 | - | 2 | - | - | - | - | 3 | - | - | - | 2 | - | - | - | 2 | 2 | - | 3 | 3 | - | - | 4 | - |
| Phlyctella subuncinata | - | - | - | - | - | 2 | - | - | - | - | 1 | - | - | - | 5 | 2 | - | - | - | - | - | - | 2 | - | 2 |
| Pseudocyphellaria billardieri | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| P. delisea | 2 | 1 | 1 | 3 | - | - | 1 | - | - | 1 | 2 | - | - | - | - | 2 | 2 | 2 | - | 2 | 2 | - | - | - | - |
| Psoroma durietzii | - | - | - | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| P. microphyllizans | 1 | - | 2 | - | - | - | - | - | - | - | 1 | - | - | - | 1 | 1 | 2 | - | - | 1 | 2 | - | - | - | - |
| Pyrenula sp. | - | - | - | - | - | 1 | 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sphaerophorus ramulifer | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| S. tener | - | 1 | 2 | 1 | 1 | - | - | - | - | 1 | 1 | - | 1 | - | - | 2 | 2 | 2 | - | - | 2 | - | - | 1 | - |
| Thelotrema lepadinum | 4 | 2 | 5 | 3 | 3 | 5 | 4 | 3 | 3 | 2 | 2 | 2 | - | - | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 4 | 4 | - | 3 |
| Usnea sp. | - | 1 | - | 1 | 2 | - | - | - | - | 1 | - | 1 | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| Species B | - | - | - | - | - | 1 | - | 2 | 2 | - | - | 3 | 3 | - | - | - | - | - | - | 2 | - | - | 3 | - | 2 |
| Bryophytes | - | 1 | 1 | 1 | 4 | 2 | 1 | 2 | - | 2 | 1 | - | - | 2 | 2 | 2 | 3 | 2 | - | 2 | 2 | 2 | - | - | - |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

the succession of epiphytic lichen vegetation. Some of the species discussed, in particular Thelotrema lepadinum and Coccotrema cucurbitula, are widespread and ubiquitous pioneers in a range of forests. Others, such as Bacidia weymouthii, Phlyctella subuncinata and Megaloblastenia marginiflexa, are widespread but confined mainly to Atherosperma and Tasmannia. Additional common lichens which behave as pioneers but which were not recorded at Little Fisher River include Megalospora lopadioides (in thamnic and implicate forests, particularly at high altitudes), Arthothelium spp., Pyrenula sp. and Graphis scripta (mainly on Atherosperma), Bacidia sp.1 and Phaeographis exaltata (mainly in thamnic forests) and Catillaria kelica (widespread). Many additional crustose species from forests outside the Little Fisher Valley have not been determined and some may have been overlooked. To ascertain the communities involved requires a great deal of further work, a task beyond the scope of the present project.

Neither the Opegrapha - Coccotrema community, nor any related pioneer community, was sampled in the study discussed in part IIIB.

(11) Pannoparmelia angustata community (Table 23)

The Pannoparmelia angustata community represents the pioneer vegetation of exposed, high canopy, foliage-bearing twigs. Its character species include Pannoparmelia angustata, Haematomma infuscum, Usnea molliuscula, Lecidea laeta, Fuscidea sp. and Ochrolechia sp. Several additional macrolichens, e.g. Parmelia labrosa, P. subglabra, Hypogymnia turgidula and species of Menegazzia, also occur in the community as juvenile thalli surrounding the bases of petioles or leaf scars. Pertusaria nothofagi is common but is usually present on slightly older wood, well behind the growing tip of the twig. Additional crustose lichens may well have been overlooked because many thalli occur as ill-defined, undeterminable, sterile "smudges". In general, the total cover of the community is less than 60%, with bryophytes being absent or represented by juvenile Radula sp. only.

The high diversity and cover of macrolichens in the community contrasts noticeably with the almost totally crustose Opegrapha stellata - Coccotrema cucurbitula pioneer community of similar young twigs within the forest interior. However, the two communities have some similarities, with a few species in common, e.g. Parmelia

Table 23. Pannoparmelia angustata community.

| SPECIES | STANDS * | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 108 | 283 | 284 | 285 | 286 | 288 | 290 | 304 | 307 | 309 |
| Catillaria sp. 1 | - | - | - | 2 | - | - | - | - | - | - |
| Catinaria sp. | 1 | - | - | 2 | - | - | - | - | - | - |
| Coccotrema cucurbitula | - | - | - | - | - | - | 1 | - | - | - |
| Fuscidea sp. | - | - | 2 | - | - | - | 3 | - | 2 | 2 |
| Haematomma infuscum | - | 2 | 2 | - | - | 2 | 3 | - | 2 | 2 |
| Hypogymnia turgidula | 3 | - | 3 | - | - | - | 3 | 2 | 2 | 3 |
| Lecanora atra | - | - | - | - | - | - | - | - | - | 2 |
| Lecidea sp. 1 | - | - | - | 2 | - | - | - | - | - | - |
| L. laeta | - | 2 | 3 | - | 3 | - | 2 | 2 | - | - |
| Lecidella elaeochroma | - | - | - | - | - | - | - | 2 | 2 | - |
| Menegazzia globulifera | - | - | - | - | - | - | - | - | 2 | - |
| M. platytrema | - | - | - | - | - | - | - | 3 | 2 | - |
| M. retipora | - | 1 | - | - | - | 1 | - | 2 | 1 | - |
| M. weindorferi | 3 | 3 | 2 | 3 | 3 | 3 | - | - | 3 | 5 |
| Mycoblastus sp. 1 | 1 | - | - | - | - | - | - | - | - | - |
| Ochrolechia sp. | - | 2 | 2 | - | - | 1 | - | - | - | - |
| **Pannoparmelia angustata** | **2** | **2** | **3** | **2** | **-** | **3** | **2** | **2** | **3** | **2** |
| Parmelia cunninghamii | 1 | - | - | - | - | - | - | - | - | - |
| P. labrosa | - | 2 | 2 | 3 | 3 | 3 | 3 | 2 | - | - |
| P. subglabra | - | 3 | - | 2 | 2 | 2 | - | - | - | - |
| P. tenuirima | - | - | - | - | 2 | - | 1 | - | - | - |
| Pertusaria nothofagi | 3 | - | - | 2 | 3 | 3 | - | 2 | 3 | - |
| Sphaerophorus tener | 3 | - | - | - | - | - | - | - | - | - |
| Usnea sp. | - | 2 | - | 2 | - | 2 | - | 2 | - | 2 |
| U. molliuscula | - | 1 | - | - | 2 | 2 | - | 2 | 2 | - |
| Bryophytes | - | - | - | 2 | - | 2 | - | 2 | - | - |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

labrosa and P. subglabra. Stands intermediate between the two communities have also been observed. With aging of the substrate, the canopy twigs become shaded by new leafy growth above. Pertusaria nothofagi, Menegazzia weindorferi and other lichens gradually encroach over the pioneer species and the community gradually merges into the Parmelia testacea - Pertusaria nothofagi community.

Data for this community were derived entirely from recently fallen branches and leafy twigs of Nothofagus. Thus information on the height of these twigs in the forest, the variability between floras from different phorophytes, or other habitat factors could not be obtained. Nor could the degree to which the sampled stands represent "average" twigs be assessed. Hence the description provided above is limited and further work is required to adequately circumscribe the communities of high canopy twigs.

Similar limitations apply to information on this community (or its relatives) in other rainforests. However, additional common lichens which have been recorded include Usnea arida (widespread and usually dominant), U. capillacea (widespread and common, particularly in thamnic or implicate rainforest), U. rubicunda (local in northern Tasmania), Parmelia sinuosa (widespread but local) and Menegazzia platytrema (common and widespread). The crustose species remain under-collected and many entities await determination. Some aspects of Group 10 in part IIIB pertain to this type of lichen community.

## 2. Additional lichen vegetation

As well as the epiphytic communities already discussed, other lichen vegetation is also present in the study area on the forest floor and on rotting stumps of Eucalyptus. However, this is regarded as essentially non-rainforest vegetation (see p.123) and only a brief summary of observations is given below.

### (a) Lichens on the forest floor

In general, the ground flora in most rainforests contains only sporadic occurrences of lichens. This is presumed to be due to the inability of lichens to successfully compete with bryophytes in extreme shade and moisture. However, in the study area, the forest canopy is relatively sparse, frequent clearings are present and the river provides a break in the canopy as well as producing bare rocks and earth by scouring the bank. Thus in several places, conditions

Table 24. Lichens of the forest floor.

| SPECIES | STANDS * | | | | | | |
|---|---|---|---|---|---|---|---|
| | ROCKS | | PEAT & SOIL | | | | |
| | 254 | 308 | 14 | 17 | 305 | 306 | 321 |
| Baeomyces heteromorphus | 2 | 4 | – | – | – | – | – |
| Cladia aggregata | – | 2 | 2 | 2 | 3 | 2 | 2 |
| Cladina confusa | – | – | – | – | 5 | – | – |
| Cladonia carassensis | – | – | – | – | 2 | 3 | – |
| C. ochrochlora | 2 | – | – | – | – | – | – |
| C. scabriuscula | – | – | 4 | 1 | 2 | – | 2 |
| C. squamosula | – | – | – | – | – | 1 | – |
| C. subdigitata | – | – | – | – | – | 1 | 2 |
| Gymnoderma melacarpum | – | – | – | – | – | 2 | – |
| Peltigera dolichorhiza | – | – | – | 2 | – | – | – |
| Placopsis gelida | 2 | 3 | – | – | – | – | – |
| Pseudocyphellaria delisea | – | 2 | – | – | – | – | – |
| P. cf. insculpta | 2 | – | – | – | – | – | – |
| P. subvariabilis | 6 | – | – | – | – | – | – |
| Sphaerophorus tener | 2 | – | 2 | 6 | – | 1 | 2 |
| Stereocaulon corticatulum | – | 3 | – | – | – | – | – |
| S. ramulosum | 2 | 3 | – | – | – | – | – |
| Sticta stipitata | 1 | – | – | – | – | – | – |
| Bryophytes | 3 | 4 | 5 | 3 | 2 | 4 | 5 |

* Species are scored for percentage cover using the modified Braun-Blanquet scale (see Table 9).

are suitable for ground lichens, and species belonging essentially to the neighbouring open eucalypt forest establish and can become locally abundant.

Table 24 lists the floras of seven samples from the forest floor. The table is not a summary of specific communities but is simply an inventory of the species involved and their relative abundances. The rainforest ground flora can be divided into two groups: that found on rocks and fresh earth and that occurring over peat or soil.

Rocks and soil are exposed by the uprooting of trees and the erosion of the river bank. These substrates are usually first colonised by Placopsis gelida, Stereocaulon ramulosum, Baeomyces heteromorphus and Lecidea leptocarpa. In time, mosses encroach over these sites and their advance is accelerated where a restored forest canopy induces shaded, humid conditions. The surface is soon obscured by a thick mossy turf, intermixed with litter and the fern Hymenophyllum peltatum. As the rocky character of the substrate is lost, the obligately saxicolous or terricolous species are replaced by lichens more characteristic of the Pseudocyphellaria dissimilis - Peltigera dolichorhiza community (see stands 254 and 308 in Table 24).

Examples of the lichen flora of peat and soil are contained in stands 14, 17, 305, 306 and 321 in Table 24. The flora contains many species from the family Cladoniaceae, e.g. Cladina confusa, Cladonia scabriuscula, C. carassensis, C. subdigitata and, rarely, C. corniculata and C. pleurota. Other common species present include Sphaerophorus tener and Cladia aggregata. However, except in very well-lit clearings, the flora typically consists of proliferations of a single species, most commonly either Cladina confusa or Cladonia scabriuscula. Bryophytes remain the dominant forest floor plants and conspicuous species include Ptychomnion aciculare and Dicranoloma billardieri. Associated dicotyledons include Lagenophora stipitata and Oxalis lactea. Some peat mounds show floristic similarities to eucalypt stumps (see below) presumably because they have been derived from decomposed stumps or from litter cones at the bases of eucalypts.

(b) Lichens on eucalypts

Stumps and logs of Eucalyptus delegatensis are scattered through the study area and support an impoverished lichen flora which differs from that on any other tree species. Most stands investigated consisted almost entirely of a single species. Lichens recorded were Cladia aggregata, Cladonia squamosula, C. subdigitata, Gymnoderma melacarpum, Lecidea cf. granulosa and Lepraria incana.

3. Problems in the classification of lichen communities

The epiphytic communities described in the preceding discussion have each shown substantial intergradation with communities which surround them both in time or space. To some extent this problem is universal in the classification of any vegetation. However, the classification of lichen communities is confronted with additional, specific difficulties.

One important problem is that the size of the thallus of a lichen is sometimes larger than the area of a microhabitat to which it responds. This is particularly evident in the case of species which favour dry bark but which are also able to exploit locally drier spots in the surface of an otherwise wet aspect. Such "micro-sites" can be created simply by faint depressions or projections in the bark which deflect the course of water flowing down the trunk. In this way, apparently anomalous or heterogeneous stands occur.

A more general problem is that succession in any vegetation produces a flora which is a product of both present and preceding habitat conditions. Due to the persistence of some species and the slow establishment of others, it is rare to find a stand which fully expresses the habitat conditions of that point in time. For example, Thelotrema lepadinum is clearly a pioneer species but it is also extremely persistent in the face of decortication or encroachment by species from later stages of succession. Hence it effectively becomes a ubiquitous species although it is clearly moribund and in decline in all but a few communities. In general, succession in lichen communities tends to be very complex because it entails not only aging of the lichen vegetation itself but also changes in the substrate (as the phorophyte ages) and changes in the surrounding forest vegetation.

The frequent intermixing of species from different communities is another common problem encountered in lichen studies. Lichens have dispersal ranges which are potentially measurable in thousands of kilometres and thus no community is effectively isolated from contamination by diaspores from alien communities. This applies to intermixing between different communities within the forest (separated by distances of several metres) and between rainforest and non-rainforest communities (separated by distances of perhaps several kilometres). Consequently, the chance establishment of extraneous species is probably more likely in lichen communities than it is in other vegetation, e.g. in higher plant communities, where the dispersal ranges of the constituent plants is frequently smaller than the extent of their separation.

# NUMERICAL ANALYSES

## Classification

The aim of this section is to provide an objective classification of the same data set which was used for the intuitive, phytosociological classification described above. The relative merits of the two techniques are then compared.

### 1. Methods

317 quadrats were used in this analysis and are henceforth referred to as the "total data". This data set excluded only those saxicolous or terricolous quadrats which were floristically unrelated to epiphytic communities. Quadrats and species were classified by Lance and Williams' Generalised Sorting Strategy (Lance and Williams 1966) using "percentage difference" (after Pielou 1984) and the "two-step" (Austin and Belbin 1982) dissimilarity measures for quadrats and species respectively (see Appendix 2). Quadrats were classified into 12 groups. Species were initially classified into 20 groups but this figure was reduced to 17 after some manual resorting.

### 2. Results

The results of the classification are presented in Tables 25 and 26 which show the mean percentage cover and frequency of each species in each group. Groups have been arranged so that maximum values descend the diagonal from left to right. The interpretation of the groups is as follows:

Quadrats:

| | |
|---|---|
| Group 1: | Pannoparmelia angustata community |
| Group 2: | Parmelia testacea - Pertusaria nothofagi community |
| Groups 3 & 4: | Opegrapha stellata - Coccotrema cucurbitula community |
| Group 4: | Atherosperma - preferential facies of the Opegrapha - Coccotrema community |
| Group 5: | Pseudocyphellaria rubella - P. faveolata community |
| Group 6: | P. billardieri - Psoroma microphyllizans community |
| Group 7: | Pseudocyphellaria subvariabilis - Psoroma microphyllizans community |

Group 8: Pseudocyphellaria dissimilis - Peltigera dolichorhiza community
Group 9: Sphaerophorus insignis community
Group 10: Conotremopsis weberiana community
Group 11: Lecanactis abietina - Sagenidium molle community
Group 12: Sphaerophorus ramulifer - S. tener community

Species:
Group 1: Characteristic species of quadrat group 1
Group 2: Characteristic species of quadrat group 2
Group 3: Rare species found mainly in quadrat groups 2 and 3
Group 4: Characteristic species of quadrat groups 3 and 4
Group 5: Species widespread in quadrat groups 1-4
Group 6: Characteristic species of quadrat group 4
Group 7: Wide-ranging rare species, found mainly on young or dry wood (cf. species group 13)
Group 8: Characteristic species of quadrat group 5
Group 9: Characteristic species of quadrat group 6
Group 10: Characteristic species of quadrat group 7
Group 11: Characteristic species of quadrat group 8
Group 12: Characteristic species of quadrat group 9
Group 13: Rare, widespread species found mainly in communities on old, wet wood (cf. species group 7)
Group 14: Characteristic species of quadrat group 10
Group 15: Species occurring in communities on dry wood (quadrat groups 10 and 11)
Group 16: Characteristic species of quadrat group 11
Group 17: Widespread, common species.

## 3. Discussion

The quadrat groups of the numerical classification accord closely with those resulting from the phytosociological classification. (The community descriptions given in the preceding section are applicable here and are not repeated.)

The classification was initially retrieved at several levels but beyond the 12-group level, the classes become trivial or not recognisable in the field. At the 11-group level the Pseudocyphellaria dissimilis group (no. 8) is fused with the P. subvariabilis group (no. 7), indicating that this is the weakest

Table 25. Numerically derived classification of "total" data set from Little Fisher River showing percentage frequency of species in each group. See p. 163 for a key to group numbers.

| SPECIES GROUPS | SPECIES | QUADRAT GROUPS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | Haematomma infuscum | 86 | - | - | 10 | - | - | - | - | - | - | - | - |
| | Pannoparmelia angustata | 100 | 24 | - | - | - | - | - | - | - | - | - | - |
| 1 | Menegazzia retipora | 57 | - | 6 | - | - | - | - | - | - | - | - | - |
| | Lecidea laeta | 57 | 5 | - | - | - | - | - | - | - | - | - | - |
| | Ochrolechia sp. | 43 | - | - | 5 | - | - | - | - | - | - | - | - |
| | Usnea molliuscula | 71 | - | - | - | - | - | - | - | - | - | - | - |
| | Fuscidea sp. | 57 | - | - | - | - | - | - | - | - | - | - | - |
| | Hypogymnia turgidula | 71 | 43 | 22 | - | 15 | - | - | - | 8 | 10 | - | 17 |
| | Parmelia testacea | - | 67 | 20 | 5 | 5 | 8 | 4 | - | 4 | 4 | - | 14 |
| | Menegazzia weindorferi | 71 | 100 | 54 | - | 30 | - | - | - | - | 6 | - | 7 |
| 2 | Pertusaria nothofagi | 43 | 100 | 54 | 25 | 30 | 4 | 4 | - | 4 | 6 | - | 21 |
| | Usnea sp. | 57 | 43 | 62 | 5 | 20 | - | - | - | 8 | 4 | - | 21 |
| | Parmelia cunninghamii | - | 19 | 22 | - | 5 | - | - | - | 4 | 8 | - | 5 |
| | P. tenuirima | 14 | 62 | 10 | - | 10 | 8 | - | - | - | - | - | - |
| | Hypogymnia mundata | - | 10 | 2 | - | - | - | - | - | - | - | - | - |
| 3 | Lecidea sp. 1 | - | 19 | 2 | - | - | - | - | - | - | - | - | - |
| | Mycoblastus sp. 1 | - | 14 | 8 | - | - | - | - | - | - | - | - | - |
| | Menegazzia globulifera | 14 | 10 | 8 | - | 10 | - | - | - | 4 | 2 | - | 2 |
| 4 | Opegrapha stellata | - | - | 66 | 70 | 5 | 12 | - | - | - | 2 | - | 12 |
| | Coccotrema cucurbitula | 14 | 10 | 70 | 55 | 20 | 31 | 8 | - | - | - | - | 7 |
| | Catillaria sp. 1 | - | 10 | 14 | 20 | - | - | - | - | - | - | - | - |
| | Parmelia subglabra | 29 | 19 | 18 | 15 | - | - | - | - | - | - | - | - |
| 5 | Catinaria sp. | - | 33 | 14 | 25 | - | 4 | - | - | - | - | - | - |
| | Parmelia labrosa | 71 | 24 | 34 | 40 | - | 4 | - | - | - | - | - | - |
| | Austroblastenia pauciseptata | - | - | 26 | 25 | - | 15 | - | - | - | 2 | - | 5 |
| | Bacidia weymouthii | - | - | 10 | 85 | - | 27 | - | - | - | 4 | - | - |
| 6 | Phlyctella subuncinata | - | - | 10 | 50 | - | 19 | - | - | - | - | - | - |
| | Chiodecton colensoi | - | - | 4 | 50 | - | 4 | - | - | - | - | - | - |
| | Species B | - | 5 | - | 40 | - | - | - | - | - | - | - | - |
| | Arthothelium sp. 1 | - | - | 12 | 10 | - | 4 | - | - | - | - | - | 5 |
| | Catinaria pulverea | - | - | 6 | - | - | 4 | - | - | - | 2 | - | 5 |
| | Menegazzia nothofagi | - | - | 6 | - | - | - | - | - | - | 2 | - | 5 |
| 7 | Cetraria chlorophylla | - | 5 | 2 | 5 | - | - | - | - | - | 4 | - | - |
| | Lecidea sp. 4 | - | - | - | - | - | - | - | - | - | - | 13 | - |
| | Cliostomum griffithii | - | - | 2 | 10 | - | - | - | - | - | - | 9 | - |
| | Dimerella lutea | - | - | 4 | 10 | - | 8 | - | - | - | 4 | - | 5 |
| | Megaloblastenia marginiflexa | - | - | 2 | 25 | - | 4 | - | - | - | - | - | - |
| | Lecanora atra | 14 | - | 4 | - | - | 4 | - | - | - | - | - | - |
| | Pyrenula sp. | - | - | - | 10 | - | 4 | - | - | - | - | - | - |
| | Leioderma amphibolum | - | 57 | 10 | - | 35 | 4 | 8 | - | 16 | 4 | - | 43 |
| | Psoroma durietzii | - | - | 14 | 5 | 40 | - | 4 | - | 16 | 2 | - | 19 |
| 8 | Pseudocyphellaria faveolata | - | - | - | - | 45 | 4 | - | - | - | - | - | - |
| | P. rubella | - | - | - | - | 55 | 4 | - | - | - | - | - | - |
| | Psoroma leprolomum | - | - | - | - | 25 | - | - | - | - | - | - | 2 |
| | Nephroma australe | - | - | 2 | - | 35 | 19 | 16 | - | - | - | - | - |
| | Pseudocyphellaria billardieri | - | - | 6 | 5 | 50 | 73 | 20 | - | - | - | - | 10 |
| | Collema laeve | - | - | - | - | - | 12 | - | - | - | - | - | - |
| 9 | Psoromidium aleuroides | - | - | - | - | - | 19 | - | - | - | - | - | - |
| | Parmeliella nigrocincta | - | - | - | - | - | 23 | 4 | 33 | 4 | - | - | 5 |
| | Psoroma microphyllizans | - | 38 | 36 | 35 | 15 | 100 | 64 | 100 | 8 | 12 | - | 95 |
| | Sticta stipitata | - | - | - | - | 5 | 42 | 44 | 100 | - | - | - | 2 |
| 10 | Pseudocyphellaria crocata | - | - | - | - | 15 | 12 | 16 | - | 8 | - | - | 2 |
| | P. subvariabilis | - | - | - | - | - | 12 | 48 | 50 | 4 | - | - | 2 |
| | Cladonia scabriuscula | - | - | - | - | - | - | 24 | - | - | - | - | - |
| | Peltigera dolichorhiza | - | - | - | - | - | - | 32 | 50 | - | - | - | - |
| 11 | Pseudocyphellaria dissimilis | - | - | - | - | - | 4 | 24 | 100 | - | - | - | - |
| | Dendriscocaulon dendriothamnodes | - | - | - | - | 5 | - | 8 | 33 | 4 | - | - | - |
| | Leptogium limbatum | - | - | - | - | - | 4 | 12 | 33 | - | - | - | - |
| | Placopsis gelida | - | - | - | - | 5 | - | 8 | - | - | - | - | - |
| | Stereocaulon ramulosum | - | - | - | - | - | - | 8 | 17 | - | - | - | - |
| | Cladia aggregata | - | - | - | - | 30 | - | 56 | - | 84 | 20 | - | 14 |
| 12 | Sphaerophorus insignis | - | - | 10 | - | 5 | 19 | 52 | - | 92 | 37 | - | 38 |
| | Psoroma asperellum | - | - | - | - | 15 | 4 | 40 | - | 32 | 4 | - | 31 |
| | Cladonia chlorophaea | - | - | - | - | - | - | - | - | 24 | - | - | 5 |
| | Micarea prasina aggr. | - | 5 | - | - | 5 | - | - | - | 8 | - | - | 19 |
| 13 | Phyllopsora congregans | - | - | - | - | - | - | - | - | 44 | - | - | 2 |
| | Sphaerophorus melanocarpus | - | - | - | - | - | - | 12 | - | 24 | - | - | 12 |
| | Pseudocyphellaria argyracea | - | - | - | - | - | - | 16 | - | - | - | - | 2 |
| | Sphaerophorus patagonicus | - | - | - | - | - | - | 12 | - | - | - | - | - |
| | Pertusaria sp. 1 | - | 5 | 2 | - | - | - | 4 | - | 8 | - | - | - |
| | Psoroma paleaceum | - | - | - | - | 10 | 8 | 16 | - | 8 | - | - | - |
| | Thelotrema subdenticulatum | - | - | - | - | - | 4 | 16 | - | 28 | 2 | - | 2 |
| 14 | Conotremopsis weberiana | - | - | - | - | - | - | - | - | 12 | 60 | 13 | 19 |
| | Micarea mutabilis | - | 5 | 6 | - | - | - | - | - | 12 | 40 | - | 12 |
| 15 | Catillaria sp. 3 | - | - | - | - | - | - | - | - | 4 | 21 | 17 | - |
| | Arthonia sp. 1 | - | - | - | - | - | - | - | - | - | 50 | 39 | - |
| | Chaenotheca brunneola | - | - | - | - | - | - | - | - | - | - | 48 | - |
| | Arthonia cinereopruinosa | - | - | - | - | - | - | - | - | - | 4 | 35 | - |
| 16 | Catillaria sp. 4 | - | - | - | - | - | - | - | - | - | 6 | 22 | - |
| | Coniocybe furfuracea | - | - | - | - | - | - | - | - | - | 4 | 65 | - |
| | Lecanactis abietina | - | - | - | - | - | - | - | - | - | 10 | 87 | - |
| | Sagenidium molle | - | - | - | - | - | - | - | - | - | 21 | 61 | - |
| | Cladonia ochrochlora | - | 19 | 4 | - | 40 | 4 | 24 | - | 48 | 31 | 4 | 48 |
| | Sphaerophorus ramulifer | - | - | 22 | - | 30 | - | 16 | - | 88 | 69 | 4 | 62 |
| 17 | Lepraria incana | - | 52 | 26 | 5 | 25 | 19 | 8 | 17 | 44 | 90 | 83 | 62 |
| | Thelotrema lepadinum | - | 10 | 60 | 90 | 10 | 85 | 32 | - | 60 | 92 | 91 | 74 |
| | Pseudocyphellaria delisea | - | 38 | 82 | 30 | 100 | 81 | 76 | 33 | 92 | 33 | - | 100 |
| | Sphaerophorus tener | - | 29 | 88 | 10 | 75 | 50 | 68 | 33 | 100 | 58 | 4 | 98 |
| | NO. OF QUADRATS | 7 | 21 | 50 | 20 | 20 | 26 | 25 | 6 | 25 | 52 | 23 | 42 |

Table 26. Numerically derived classification of "total" data set from Little Fisher River showing mean percentage cover of species in each group (+ denotes < 0.5%). See p. 163 for a key to group numbers.

| SPECIES GROUPS | SPECIES | QUADRAT GROUPS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | Haematomma infuscum | 3.9 | - | - | + | - | - | - | - | - | - | - | - |
| | Pannoparmelia angustata | 7.9 | + | - | - | - | - | - | - | - | - | - | - |
| 1 | Menegazzia retipora | + | - | + | - | - | - | - | - | - | - | - | - |
| | Lecidea laeta | 3.2 | 0.7 | - | - | - | - | - | - | - | - | - | - |
| | Ochrolechia sp. | 0.7 | - | - | + | - | - | - | - | - | - | - | - |
| | Usnea molliuscula | 1.4 | - | - | - | - | - | - | - | - | - | - | - |
| | Fuscidea sp. | 3.2 | - | - | - | - | - | - | - | - | - | - | - |
| | Hypogymnia turgidula | 7.1 | 1.3 | + | - | + | - | - | - | + | + | - | + |
| | Parmelia testacea | - | 11.0 | 1.3 | + | + | + | + | - | + | + | - | + |
| | Menegazzia weindorferi | 15.7 | 11.8 | 1.5 | - | + | - | - | - | - | + | - | + |
| 2 | Pertusaria nothofagi | 4.6 | 23.7 | 9.0 | 2.5 | 2.6 | + | + | - | + | + | - | + |
| | Usnea sp. | 1.4 | + | 0.6 | + | + | - | - | - | + | + | - | + |
| | Parmelia cunninghamii | - | 1.0 | + | - | + | - | - | - | + | + | - | + |
| | P. tenuirima | + | 3.2 | 0.9 | - | + | + | - | - | - | - | - | - |
| | Hypogymnia mundata | - | + | + | - | - | - | - | - | - | - | - | - |
| 3 | Lecidea sp. 1 | - | + | + | - | - | - | - | - | - | - | - | - |
| | Mycoblastus sp. 1 | - | + | + | - | - | - | - | - | - | - | - | - |
| | Menegazzia globulifera | + | + | + | - | + | - | - | - | + | + | - | - |
| 4 | Opegrapha stellata | - | - | 7.7 | 2.6 | + | 0.8 | - | - | - | + | - | + |
| | Coccotrema cucurbitula | + | + | 6.5 | 8 | 2.4 | 2.1 | + | - | - | - | - | + |
| | Catillaria sp. 1 | - | + | + | + | - | - | - | - | - | - | - | - |
| | Parmelia subglabra | 2.5 | + | 0.6 | + | - | - | - | - | - | - | - | - |
| 5 | Catinaria sp. | - | 1.7 | + | 1.3 | - | + | - | - | - | - | - | - |
| | Parmelia labrosa | 5.4 | 1.6 | + | + | - | + | - | - | - | - | - | - |
| | Austroblastenia pauciseptata | - | - | 3.3 | 0.9 | - | + | - | - | - | + | - | + |
| | Bacidia weymouthii | - | - | + | 8.1 | - | 1.4 | - | - | - | + | - | - |
| 6 | Phlyctella subuncinata | - | - | + | 7.4 | - | 1.3 | - | - | - | - | - | - |
| | Chiodecton colensoi | - | - | + | 2.3 | - | + | - | - | - | - | - | - |
| | Species B | - | + | - | 2.9 | - | - | - | - | - | - | - | - |
| | Arthothelium sp. 1 | - | - | + | + | - | + | - | - | - | - | - | + |
| | Catinaria pulverea | - | - | + | - | - | + | - | - | - | + | - | + |
| | Menegazzia nothofagi | - | - | + | - | - | - | - | - | - | + | - | + |
| 7 | Cetraria chlorophylla | - | 0.7 | + | + | - | - | - | - | - | + | - | - |
| | Lecidea sp. 4 | - | - | - | - | - | - | - | - | - | - | 3.3 | - |
| | Cliostomum griffithii | - | - | + | 0.9 | - | - | - | - | - | - | 0.8 | - |
| | Dimerella lutea | - | - | + | 1.5 | - | + | - | - | - | + | - | + |
| | Megaloblastenia marginiflexa | - | - | + | 1.6 | - | + | - | - | - | - | - | - |
| | Lecanora atra | + | - | + | - | - | + | - | - | - | - | - | - |
| | Pyrenula sp. | - | - | - | 1.9 | - | + | - | - | - | - | - | - |
| | Leioderma amphibolum | - | + | + | - | 0.6 | + | + | - | + | + | - | + |
| | Psoroma durietzii | - | - | + | + | 0.8 | - | + | - | + | + | - | + |
| 8 | Pseudocyphellaria faveolata | - | - | - | - | 9.4 | 0.6 | - | - | - | - | - | - |
| | P. rubella | - | - | - | - | 9.5 | + | - | - | - | - | - | - |
| | Psoroma leprolomum | - | - | - | - | 1.3 | - | - | - | - | - | - | + |
| | Nephroma australe | - | - | + | - | 2.8 | + | + | - | - | - | - | - |
| | Pseudocyphellaria billardieri | - | - | + | + | 7.8 | 11.3 | 1.3 | - | - | - | - | 0.8 |
| | Collema laeve | - | - | - | - | - | + | - | - | - | - | - | - |
| 9 | Psoromidium aleuroides | - | - | - | - | - | 2.3 | - | - | - | - | - | - |
| | Parmeliella nigrocincta | - | - | - | - | - | 1.5 | + | 0.8 | + | - | - | + |
| | Psoroma microphyllizans | - | 1.3 | 1.5 | 1.1 | + | 21.9 | 3.9 | 6.3 | + | + | - | 8.5 |
| | Sticta stipitata | - | - | - | - | + | 1.1 | 1.3 | 2.1 | - | - | - | + |
| 10 | Pseudocyphellaria crocata | - | - | - | - | + | + | 0.8 | - | + | - | - | + |
| | P. subvariabilis | - | - | - | - | - | + | 21.4 | 0.8 | 0.6 | - | - | + |
| | Cladonia scabriuscula | - | - | - | - | - | - | 1.8 | - | - | - | - | - |
| | Peltigera dolichorhiza | - | - | - | - | - | - | 2.6 | 2.9 | - | - | - | - |
| 11 | Pseudocyphellaria dissimilis | - | - | - | - | - | 0.6 | 1.4 | 58.3 | - | - | - | - |
| | Dendriscocaulon dendriothamnodes | - | - | - | - | + | - | + | 0.8 | + | - | - | - |
| | Leptogium limbatum | - | - | - | - | - | + | 1.3 | + | - | - | - | - |
| | Placopsis gelida | - | - | - | - | 0.8 | - | + | - | - | - | - | - |
| | Stereocaulon ramulosum | - | - | - | - | - | - | + | - | - | - | - | - |
| | Cladia aggregata | - | - | - | - | 2.0 | - | 1.5 | - | 2.5 | 0.7 | - | 0.5 |
| 12 | Sphaerophorus insignis | - | - | + | - | + | + | 4.2 | - | 17.6 | + | - | + |
| | Psoroma asperellum | - | - | - | - | 1.0 | 0.6 | 1.7 | - | + | + | - | 1.0 |
| | Cladonia chlorophaea | - | - | - | - | - | - | - | - | + | - | - | + |
| | Micarea prasina aggr. | - | + | - | - | + | - | - | - | + | - | - | 0.7 |
| 13 | Phyllopsora congregans | - | - | - | - | - | - | - | - | 1.9 | - | - | + |
| | Sphaerophorus melanocarpus | - | - | - | - | - | - | 1.2 | - | 1.6 | - | - | 1.1 |
| | Pseudocyphellaria argyracea | - | - | - | - | - | - | + | - | - | - | - | + |
| | Sphaerophorus patagonicus | - | - | - | - | - | - | 1.3 | - | - | - | - | - |
| | Pertusaria sp. 1 | - | + | + | - | - | - | + | - | + | - | - | - |
| | Psoroma paleaceum | - | - | - | - | + | + | + | - | + | - | - | - |
| | Thelotrema subdenticulatum | - | - | - | - | - | + | 0.7 | - | + | + | - | + |
| 14 | Conotremopsis weberiana | - | - | - | - | - | - | - | - | + | 4.9 | + | 1.0 |
| | Micarea mutabilis | - | + | + | - | - | - | - | - | + | 4.6 | - | + |
| 15 | Catillaria sp. 3 | - | - | - | - | - | - | - | - | + | 0.6 | + | - |
| | Arthonia sp. 1 | - | - | - | - | - | - | - | - | - | 4.3 | 0.8 | - |
| | Chaenotheca brunneola | - | - | - | - | - | - | - | - | - | - | 5.2 | - |
| | Arthonia cinereopruinosa | - | - | - | - | - | - | - | - | - | + | 2.0 | - |
| 16 | Catillaria sp. 4 | - | - | - | - | - | - | - | - | - | + | 5.2 | - |
| | Coniocybe furfuracea | - | - | - | - | - | - | - | - | - | + | 2.5 | - |
| | Lecanactis abietina | - | - | - | - | - | - | - | - | - | + | 31.4 | - |
| | Sagenidium molle | - | - | - | - | - | - | - | - | - | 0.5 | 10.4 | - |
| | Cladonia ochrochlora | - | + | + | - | 1.4 | + | + | - | 0.9 | 0.6 | + | 1.0 |
| | Sphaerophorus ramulifer | - | - | 0.7 | - | 0.9 | - | + | - | 6.4 | 3.2 | + | 6.4 |
| 17 | Lepraria incana | - | + | + | + | + | + | - | + | 1.4 | 7.7 | 2.7 | 0.8 |
| | Thelotrema lepadinum | - | + | 10.6 | 16.6 | + | 4.6 | 1.0 | - | 1.2 | 16.2 | 11.5 | 5.8 |
| | Pseudocyphellaria delisea | - | 1.0 | 4.0 | 1.1 | 16.4 | 3.6 | 5.8 | 0.8 | 5.3 | 1.5 | - | 13.5 |
| | Sphaerophorus tener | - | 1.0 | 9.5 | + | 6.3 | 1.2 | 7.9 | + | 18.3 | 2.3 | + | 15.3 |
| | NO. OF QUADRATS | 7 | 21 | 50 | 20 | 20 | 26 | 25 | 6 | 25 | 52 | 23 | 42 |

division. This notion is supported by field observations, i.e. the Pseudocyphellaria dissimilis - Peltigera dolichorhiza community was recognised in the phytosociological section largely on the basis of observations in other forests where it was well-developed. On the other hand, the division of the Opegrapha stellata - Coccotrema cucurbitula community into two groups suggests that, as alluded to in the phytosociological section (p.154), there are grounds for recognising a separate Atherosperma - preferential facies.

As with the quadrat classification, the species classification is also in accordance with the phytosociological results, with the exception of the minor repositioning of some widespread species. However, no major character species have been relocated and the additional groups mainly represent rarer species which span several communities.

## 4. A comparison of the phytosociological and numerical approaches

A comparison of the methodology and results of the intuitive phytosociological classification and the numerical classification suggests advantages and disadvantages for both approaches.

A major advantage of the intuitive phytosociological method is that as well as species cover data, it incorporates, albeit subconciously, a great deal of additional information. This includes data on the substrate, the vigour of the species, whether they are encroaching or declining and, perhaps most importantly, background experience of other quadrats and other sites. In contrast, numerical classification acts only on the species cover data (or whichever performance measure is selected). Some proponents of an "all-objective" approach might argue that the additional data used by phytosociologists is subjective and should be dispensed with. However, in this study, the supplementary data is considered extremely beneficial. For example, it enabled the detection of the distinctive Pseudocyphellaria dissimilis - Peltigera dolichorhiza community even in its non-optimum form.

A common problem with numerical classification is that in some cases, individual quadrats appear to have been placed in the wrong group, although in this example the general composition of the groups remains unaltered. This is partly due to the approach used by the method which fuses most-alike individuals or groups of individuals in a series of steps. Thus it is possible for a quadrat to become

"stranded" on the wrong side of the hierarchy simply due to an apparently harmless fusion early in the process of agglomeration. Quadrats can also appear misclassified because the worker, on the basis of initial reconnaissance, usually possesses more information (see above) about each quadrat than that which is embodied in the species cover data on which the analysis is performed. Another difficulty with numerical classification is the production of groups whose limits are blurred. This has occurred in the present example, partly due to the use of the larger data set which contained acknowledged intermediates. These have acted to fill the gaps between the noda or communities and have made the placement of sharp boundaries tenuous. Again, this recognition of intermediate quadrats and the interpretation of the blurring is done on the basis of knowledge gained previously (mainly in the course of constructing the initial phytosociological classification). Thus the traditional phytosociologist is better equipped to recognise and account for anomalous or intermediate quadrats which so often blur and confuse the results of a numerical classification.

An advantage of the numerical approach is that all species are treated equally. The result is essentially a consensus of the distributions of all the species. It is well-equipped to account for wide-ranging species which have tendencies to occur in particular groups but which are neither constant nor faithful. It is also very successful in detecting differences in the combinations of several species. Thus despite the absence of any character species, group 12 of the numerical classification (the Sphaerophorus ramulifer - S. tener community) is readily recognised by the mutual absences of the character species of all the other groups and the concentration of high covers of wide-ranging common species. In contrast, the phytosociological approach relies heavily on the recognition of character species. These are effectively given more weight and the classification is based on their presence and absence. However, the distribution of these few species may not necessarily accord well with that of all the others. Moreover, this approach could face disaster if the initial choice of character species is poor.

A basic attraction of the numerical approach is its apparent objectivity in that given a particular prescription of data and methods of analysis, the results are supposedly repeatable by anyone (Mueller-Dombois and Ellenberg 1974). These authors (loc. cit. p.211)

suggest that this approach is particularly valuable and appealing to the "person with a limited knowledge or familiarity with his data". However, as they also point out, "the successful application of mathematical methods requires decisions...[which]...involve judgement, and any judgement is a subjective act" (loc. cit. p.212). Thus whilst the analysis itself is objective, the interpretation of the results is subjective and relies totally on the worker's understanding of his flora and his basic notions of likely groupings. For example, the decision on the final number of groups in both agglomerative and divisive classifications is essentially arbitary, despite the application of mathematical "stopping rules" (Minchin 1983). In the present study, there would have been no reason to suppose that 12 groups represented a good summary of the vegetation without the initial phytosociological background work. In other words, no amount of sophisticated mathematics can ever replace a thorough understanding of the vegetation.

The best approach to vegetation classification is with an integration of both techniques. The intuitive phytosociological approach is considered fundamental but numerical methods complement this in several ways. They assist by rapidly sorting large amounts of data into starting configurations for subsequent manual resorting. (The program TWINSPAN was used to this effect early in the present study.) They also lend a degree of creditability to the intuitive results (at least for some readers). In addition, numerical classification provides considerable support for a phytosociological classification, not in its supposed objectivity, but by reaching the same or a similar result via an alternative strategy.

**Indirect gradient analysis**

In this section, the relationships between the communities and the effects of environmental factors on the vegetation are investigated using ordination. This method is also employed to illustrate many of the assertions made previously regarding the distribution of communities and the occurrence of certain lichen growth forms in particular habitats.

## 1. Methods

The ordination method used was Non-metric Multi-dimensional Scaling (NMDS) in three dimensions, using the computer program ALSCAL. This method is considered an improvement on Detrended Correspondence Analysis used in part IIIB (P. Minchin pers. comm.) but was not employed previously because of its unavailability at the time. Furthermore, it is a relatively expensive technique when large data sets are involved. "Percentage difference" (after Pielou 1984) was used as the quadrat dissimilarity measure. The methods are discussed in more detail in Appendix 2. The analysis was performed on the "total" data set (i.e. 317 quadrats).

Ordination diagrams showing the configuration of quadrats on the three axes derived by ALSCAL were constructed. These axes each represent a trend in floristic composition occurring in response to an environmental gradient. The scores of the assessed environmental variables (see p.124) were then superimposed on the diagrams. It is unlikely that any single variable would account for any one particular gradient as the gradients can be expected to be more complex. For example, "height above ground" was demonstrated in part IIIB to be just one facet of the vertical gradient in rainforest. Nevertheless, plotting individual variables on the ordination, and noting any patterns in their distribution, can provide an insight into the probable identity of the gradients.

## 2. Results and discussion

Scatter plots of each environmental variable on the NMDS ordination are presented in Figures 13-18. Regions where particular scores are concentrated are indicated by approximate boundaries which highlight the distribution pattern of the variables.

The distribution of "substrate type" on the ordination is shown in Figure 13. In this diagram, axis 2 may entail a substrate gradient since all the saxicolous and terricolous quadrats occur at the right hand end of the axis whilst the non-*Nothofagus* quadrats are concentrated at the left. However, *Nothofagus* spans the entire range of variation. Moreover, given the predominance of *Nothofagus* in the data set (75% of the total) and the comparative similarity amongst quadrats from other substrates, this trend is viewed with caution. It is likely to be an artefact of a more fundamental gradient which is

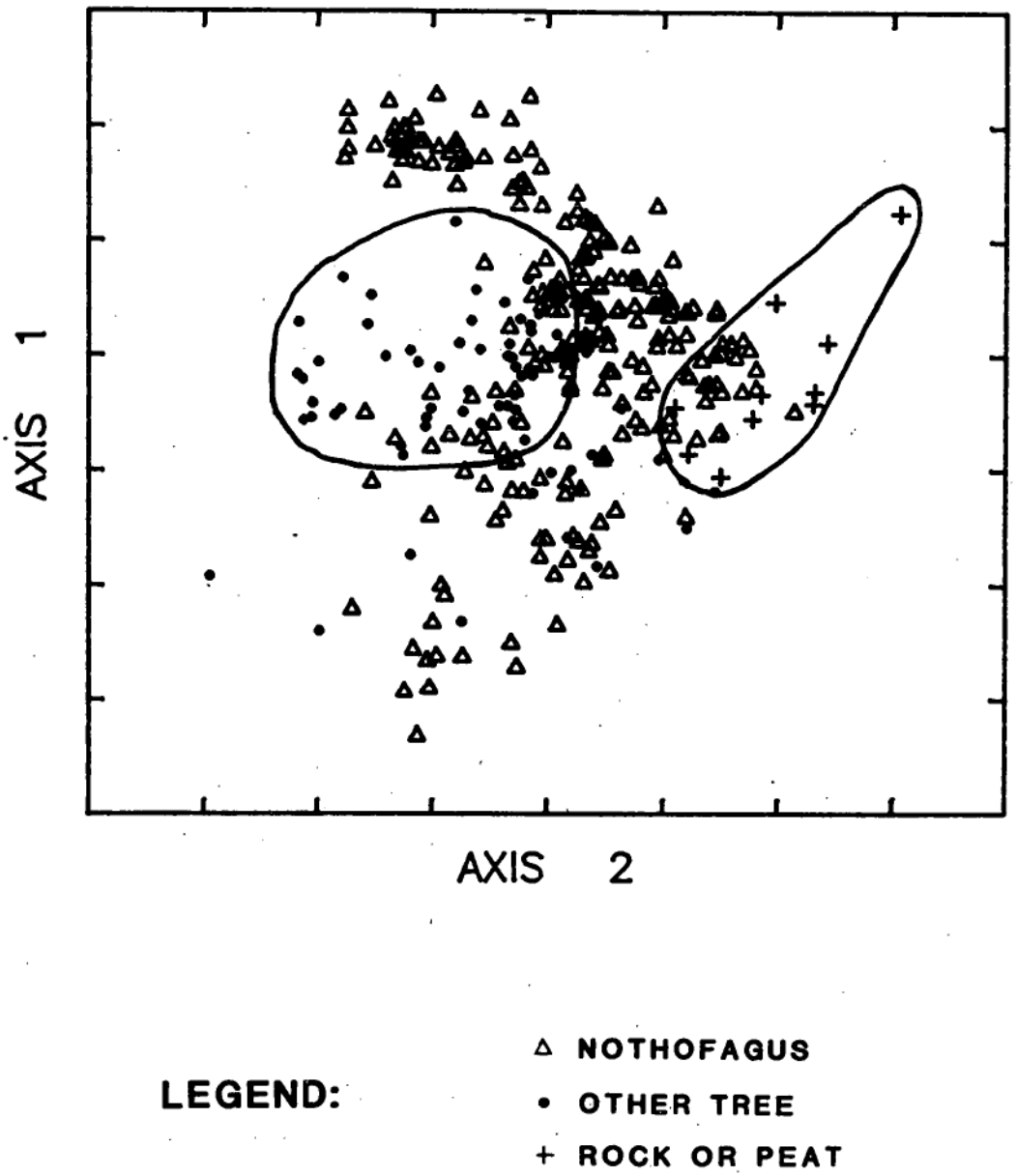



Figure 13. Distribution of "SUBSTRATE TYPE" within the configuration of quadrats defined by axes 1 and 2 of the NMDS ordination. Concentrations of particular substrates are indicated.

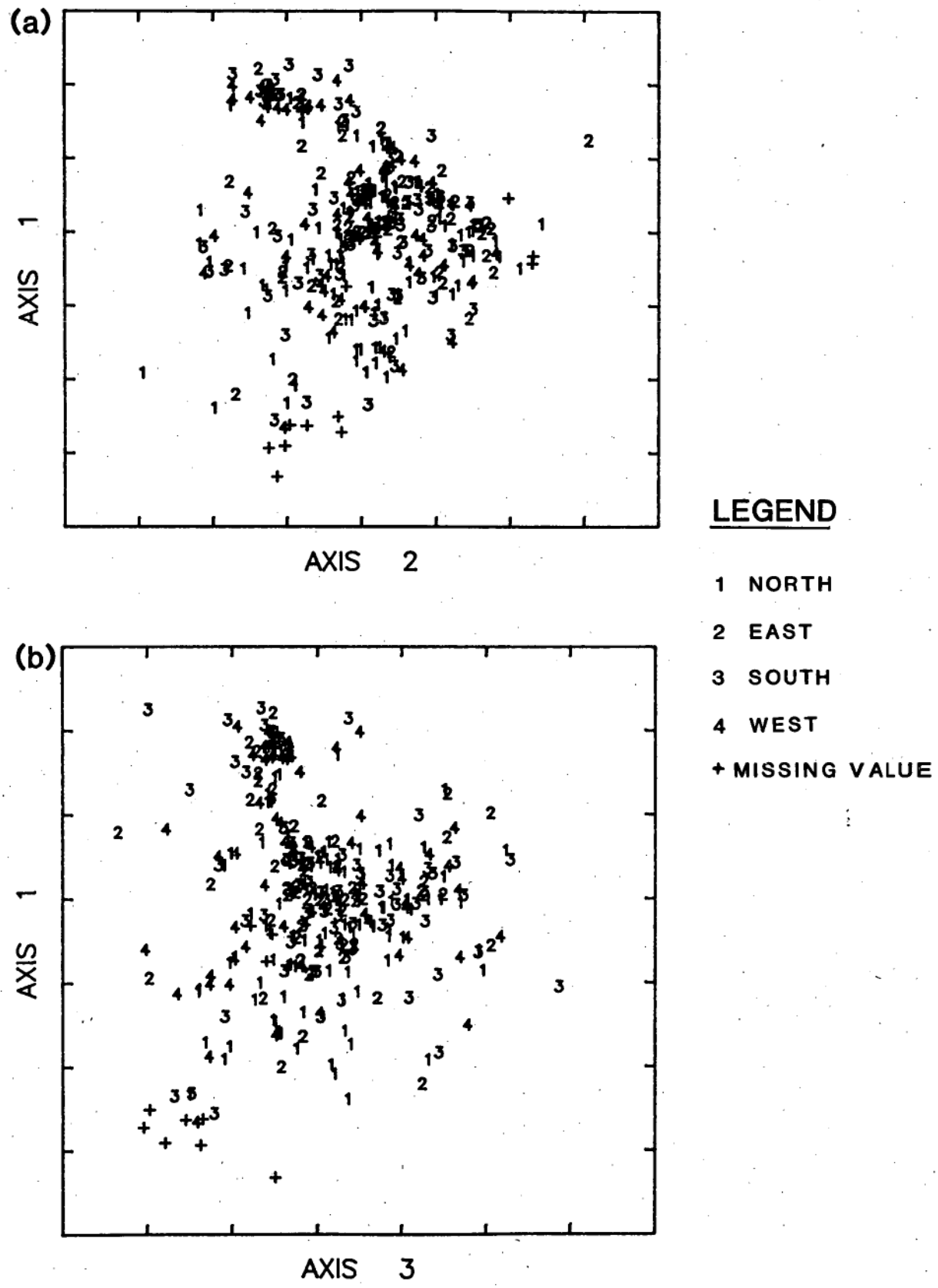



Figure 14. Distribution of "ASPECT" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination.

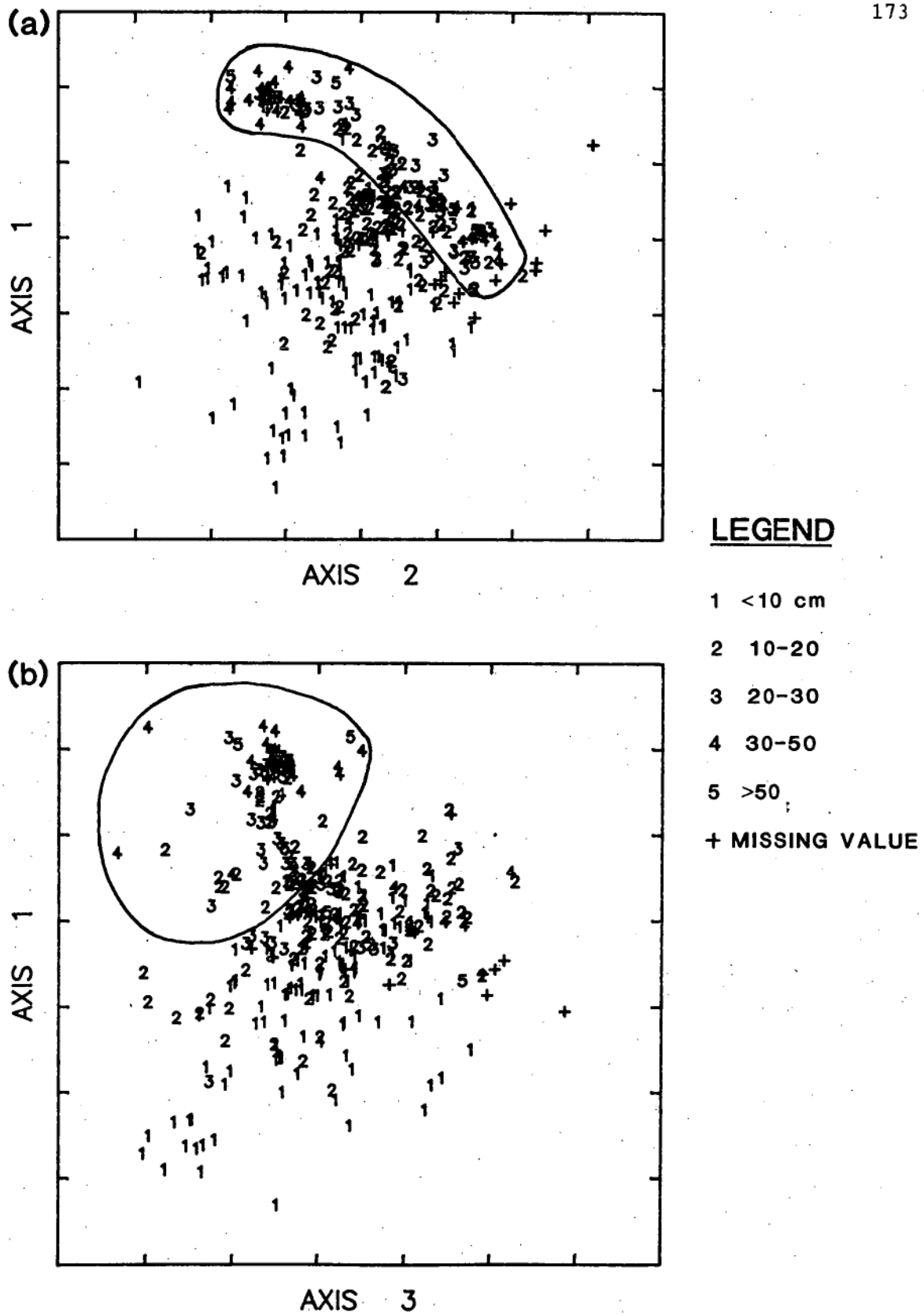



Figure 15. Distribution of "DIAMETER OF HOST" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of high diameter are indicated.

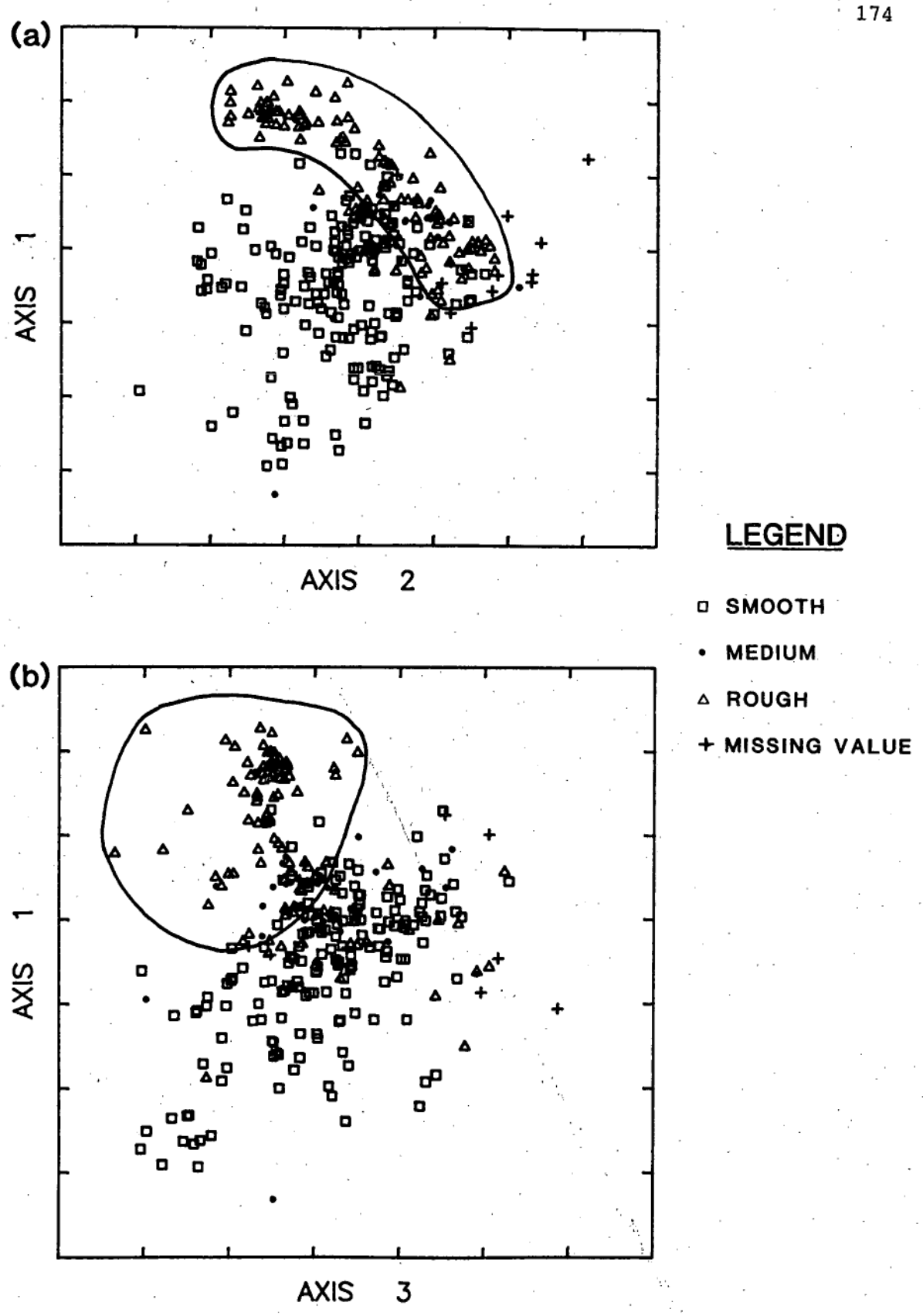



Figure 16. Distribution of "BARK TEXTURE" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Concentrations of quadrats from rough bark are indicated.

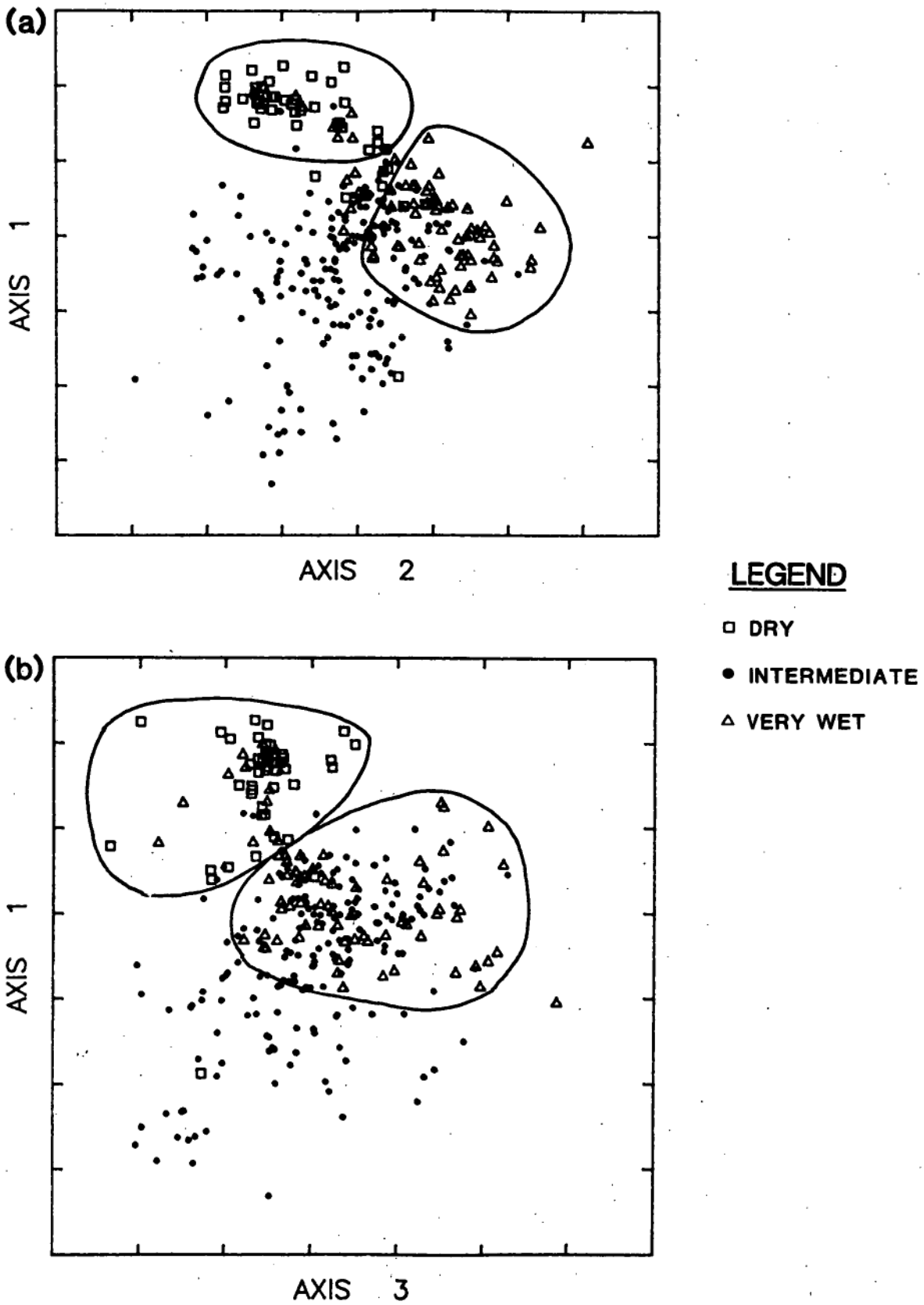



Figure 17. Distribution of "SUBSTRATE WETNESS" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Concentrations of "dry" and "very wet" quadrats are indicated.

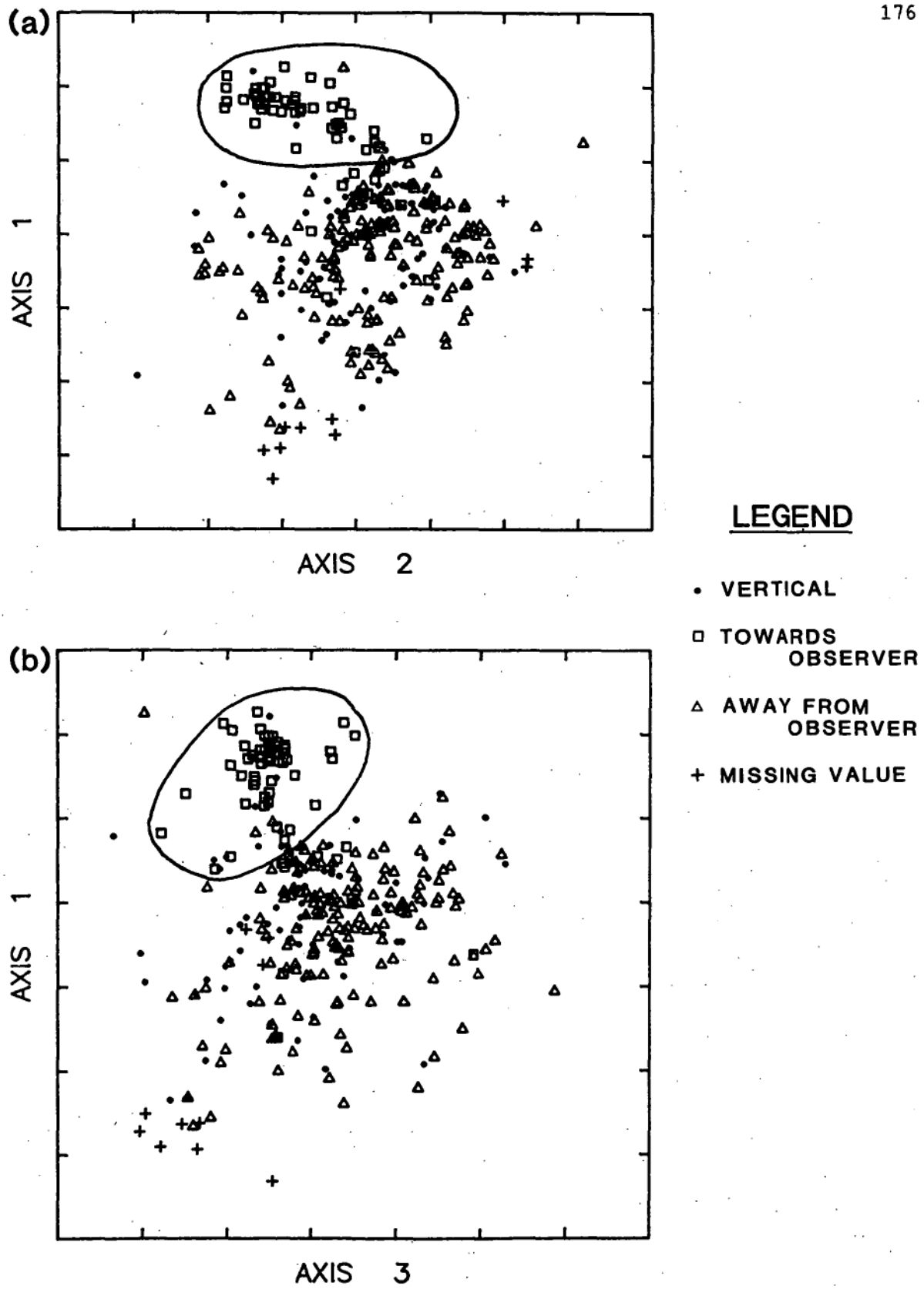



Figure 18. Distribution of "INCLINATION OF SUBSTRATE" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Concentrations of quadrats which are inclined towards the observer are indicated.

correlated with host species. No trend could be interpreted on axes 1 or 3.

The distribution of "aspect" on the ordination is shown in Figure 14. North, East, South and West facing quadrats are scattered across the diagram. This suggests that aspect on tree trunks has little influence on lichen distribution in rainforest (see also p.62). The absence of any clear-cut correlation is considered of interest given the noticeable aspect effects which have been observed in other habitats such as in open forest, on solitary trees and on rocks.

The distribution of "diameter class of the host" is shown on Figure 15. This shows some interesting trends, with approximate concentrations of large diameters in the upper part of the first axis and in the lower (left hand) part of the third axis. Thus diameter, or more likely age, appears to be involved in the environmental gradients represented by these axes. Rough bark (see Figure 16) has an almost identical distribution to large diameter. This is not surprising given that Nothofagus was the only large diameter tree in the study area and forms rough bark with age. Thus in this data set, "bark texture" and "diameter class" can be expected to embody almost the same information about the habitat.

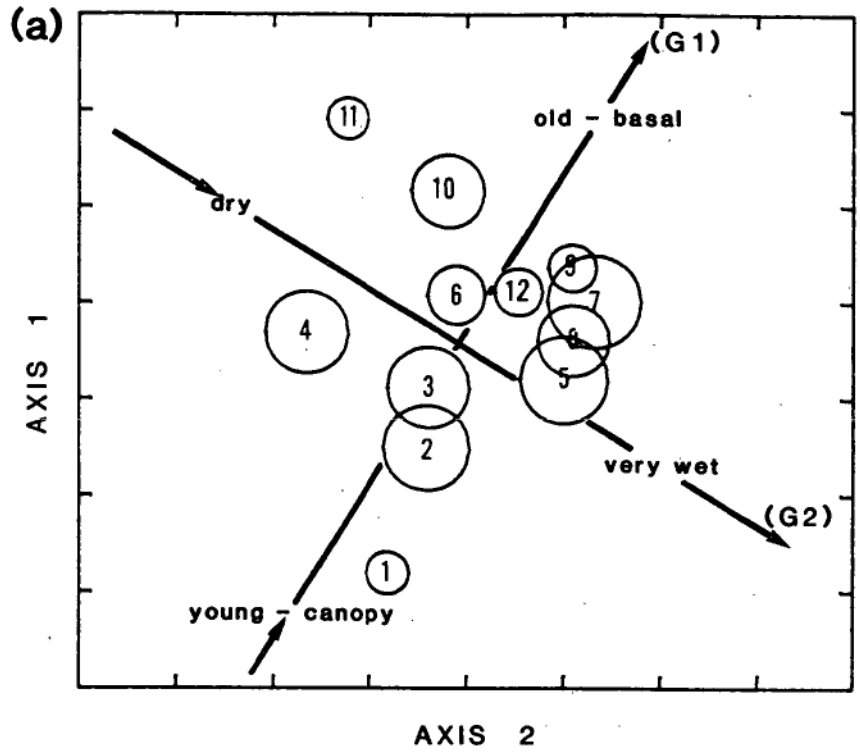
On the basis of field observations, two other variables which can be expected to be closely related are "substrate wetness" (Figure 17) and "inclination of the substrate" (Figure 18). A comparison of these two diagrams reveals that the region containing most of the dry quadrats is more or less identical to the region of quadrats which are inclined towards the observer. "Dry" and "wet" quadrats form much more tightly differentiated clusters on Figure 17(a) across axis 2 than they do on Figure 17(b) across axis 3, suggesting that moisture is a far better index of the second environmental gradient than it is of the third. Figure 18 demonstrates that with respect to "inclination", floristic differentiation occurs between those quadrats inclined towards the observer (i.e. the "dry" quadrats) and all the remaining quadrats, i.e. those which are vertical or inclined away. Thus "vertical" is not floristically intermediate between the two extreme habitats. To some extent, this is also the case for "substrate wetness" in that quadrats of intermediate wetness, while being very diverse floristically, show close affinity to many wet quadrats but scarcely any to the dry quadrats. Comparison of Figure

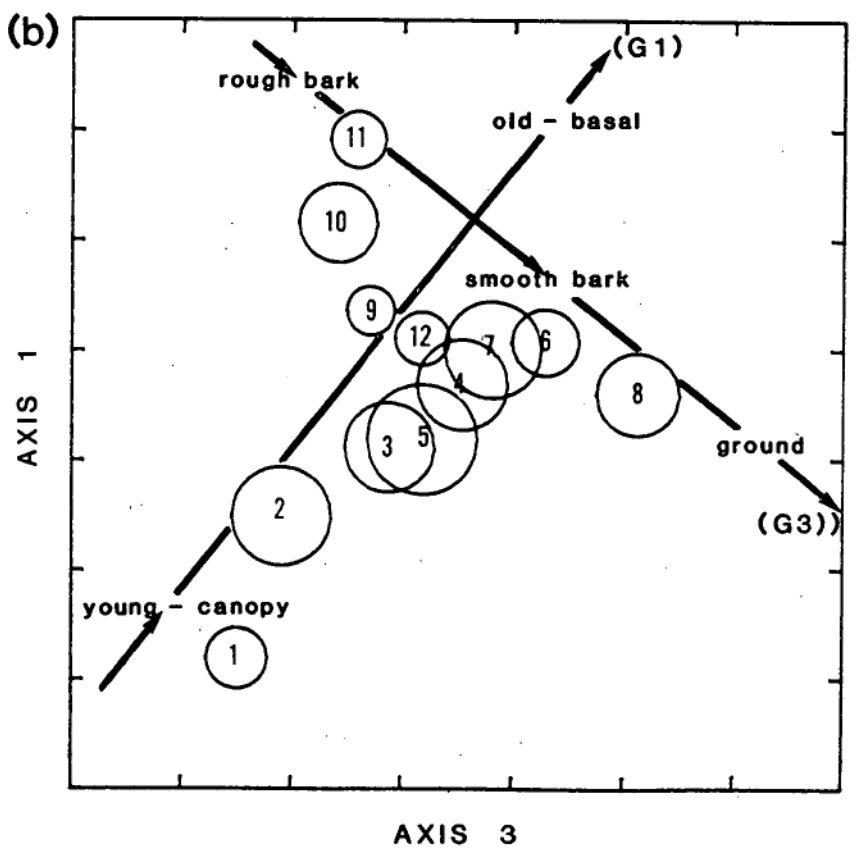
17(a) with Figures 15(a) and 16(a) also shows that the wet-dry habitat differentiation is almost completely confined to the large diameter, rough bark region of the ordination.

From the above investigation, it has become apparent that with the exception of "aspect", all the environmental variables recorded have an effect on the floristic composition of the data. However, they are inter-related to some extent. The most likely interpretations of the axes include an age gradient related to axis 1 and a moisture gradient related to axis 2. Axis 3 is more complex but appears to involve elements of age, bark texture and moisture.

An improved interpretation of the ordination is attained by combining these results with the distribution of the quadrat groups on the ordination. Figure 19 illustrates the location on the ordination of the 12 quadrat groups derived by numerical classification. Although the deduction of the environmental gradients will be detailed below, their identity is also marked on this diagram. The axes of the ordination have been rotated to maximise the change in floristic composition along the three gradients (G1, G2 and G3) which are referred to age-height, moisture and substrate respectively.

In Figure 19, the order of most of the groups along gradient 1 (G1) is consistent with an age trend in that groups 1-4 occur on young wood whereas groups 9-11 are exclusively from old wood. However, within groups 1-4, the relative positions of the pioneer Opegrapha community (3) (found on low twigs and saplings) and the Parmelia testacea community (2) (occurring on exposed, smooth trunks and main canopy branches) are inconsistent with this trend. There is an alternative interpretation of this gradient which readily accounts for the positions of these two groups. Despite most of the quadrats having been scored within the lowest 2 m of the forest, the order of communities along gradient 1 is remarkably consistent with the vertical distribution of rainforest lichen communities in general (see part IIIB). Thus groups 7-12 are basal communities whilst at the other extreme, group 1 is a canopy community which in this study was sampled from freshly fallen canopy twigs. Although group 2 was sampled from low heights, it is analogous to sub-canopy communities elsewhere. In the study area, it is confined to young, relatively open stands. Groups 3 and 4 represent pioneer communities and, on the basis of the vertical zonation study, they can be expected to appear




**KEY TO GROUPS**

1 Pannoparmelia angustata community
2 Parmelia testacea – Pertusaria nothofagi
3 Opegrapha – Coccotrema
4 Atherosperma facies of no. 3 – (Bacidia weymouthii)
5 Pseudocyphellaria rubella – P. faveolata
6 P. billardieri – Psoroma microphyllizans
7 Pseudocyphellaria subvariabilis – Psoroma microphyllizans
8 Pseudocyphellaria dissimilis – Peltigera dolichorhiza
9 Sphaerophorus insignis
10 Conotremopsis weberiana
11 Lecanactis abietina – Sagenidium molle
12 Sphaerophorus ramulifer – S. tener

Figure 19. The disposition of the 12 quadrat groups derived by numerical classification on (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Numbers mark the centroid of the co-ordinates of each group. The circle radii are equal to the Root Mean Square average of the ordination distances between individual samples and their group centroid. The interpretation of the 3 axes of the ordination is also shown.

"floristically" higher than vegetation from old wood at the same height. Group 5 and, to a lesser extent, group 6 were both initially identified as light-loving, middle to upper trunk communities (in part IIIB) which were found at low heights in the study area only where the canopy was broken.

Thus gradient 1 appears to be identical with the environmental gradient which is responsible for the vertical distribution of rainforest lichens, i.e. the complex gradient of height, light and substrate age. The location of lichen stands on this gradient can be estimated either by their height above the ground (as was the case in part IIIB) or, as in the present study, by the age (i.e. diameter) of their substrate.

The order of communities along the second gradient (G2) in figure 19(a) places groups 11,10 and 4 at one extreme and 7,8 and 5 at the other. This gradient appears to be separating the "dry communities dominated by Lecanactis abietina (no. 11) and Conotremopsis weberiana (no. 10) from the extremely wet mossy communities. The location of group 4 (the Atherosperma facies of the Opegrapha - Coccotrema community) at the dry end of the gradient initially seems anomalous although the very thin, smooth bark of Atherosperma might well provide a relatively dry habitat. The comparatively poor development of bryophytes on Atherosperma could either contribute to or result from this aridity as well. In that respect, the ordination has provided an insight into the ecology of group 4 and has suggested a possible course for future investigations. The interpretation of gradient 2 as a moisture gradient is consistent with the distribution of the environmental variables.

On the third gradient (G3) of the ordination, groups 9-11 lie at the left hand end [see Figure 19(b)]. These communities are all confined to rough bark on mature Nothofagus. The other extreme of the gradient is occupied by Group 8, the forest floor community dominated by Pseudocyphellaria dissimilis. The remaining groups, all of which occur mainly on smooth bark, lie in a band across the centre of the gradient. This gradient is best interpreted as a substrate texture gradient. This would be consistent with the distributions of the environmental variables in that old bark is invariably rough [compare Figure 15(b) and Figure 16(b) with Figure 19(b)] and that quadrats on the ground are always wet [see Figure 17(b)].

From the above deductions, the ordination diagrams can be divided into regions, viz. "dry", "moderately wet" and "very wet" across gradient 2 and "rough bark", "smooth bark" and "ground" across gradient 3. The first gradient represents the transition from young, high substrates at the lower left to old, basal substrates at the upper right. These regions have been marked on Figures 20-24 although it is emphasised that the regions are continuous and the boundaries serve as approximations rather than strict demarcation lines.

Figure 20 illustrates the distribution of bryophyte cover on the ordination. The highest percentage covers are concentrated in the wet regions of the ordination. Development of bryophytes is poorest either in very dry habitats or on the youngest, highest wood (i.e. in bottom left hand corner of the configuration). Interestingly, no relationship is evident between the cover of bryophytes and substrate texture [i.e. across gradient 3 in Figure 20(b)].

The relative success of each of the lichen growth habit classes (i.e. fruticose, foliose, crustose and leprose) is assessed in terms of diversity (see Figures 21-24). This performance measure (instead of total cover) is used because it could be readily calculated at this late stage of the investigation. (Total bryophyte cover had been recorded in the field.)

The distribution of fruticose lichen diversity is illustrated in Figure 21. Diversity is highest in epiphytic, old habitats which are basal and wet. Wet rough bark is an optimum habitat where the fruticose habit aids in the rapid removal of excess water (see also p.88). A comparison with Figure 20(a) shows that the centre of development of fruticose lichens occurs within the region of highest bryophyte cover. The diagrams support the earlier assertions that the fruticose habit confers an advantage where there is competition for substrate space (see p.88).

The diversity of foliose lichens (Figure 22) is evenly spread along the entire height-age gradient. In this discussion, "foliose" is used in a very general sense to include all spreading macrolichens which occupy space exlusively. The category includes byssoid species (e.g. Sagenidium), squamulose species and typical leafy species. A distinct region of low diversity occurs on dry bark. This area is essentially unsuitable for macrolichens and most species recorded are byssoid (Sagenidium and Conotremopsis). Foliose lichens are also poorly developed on extremely rough bark where they are often

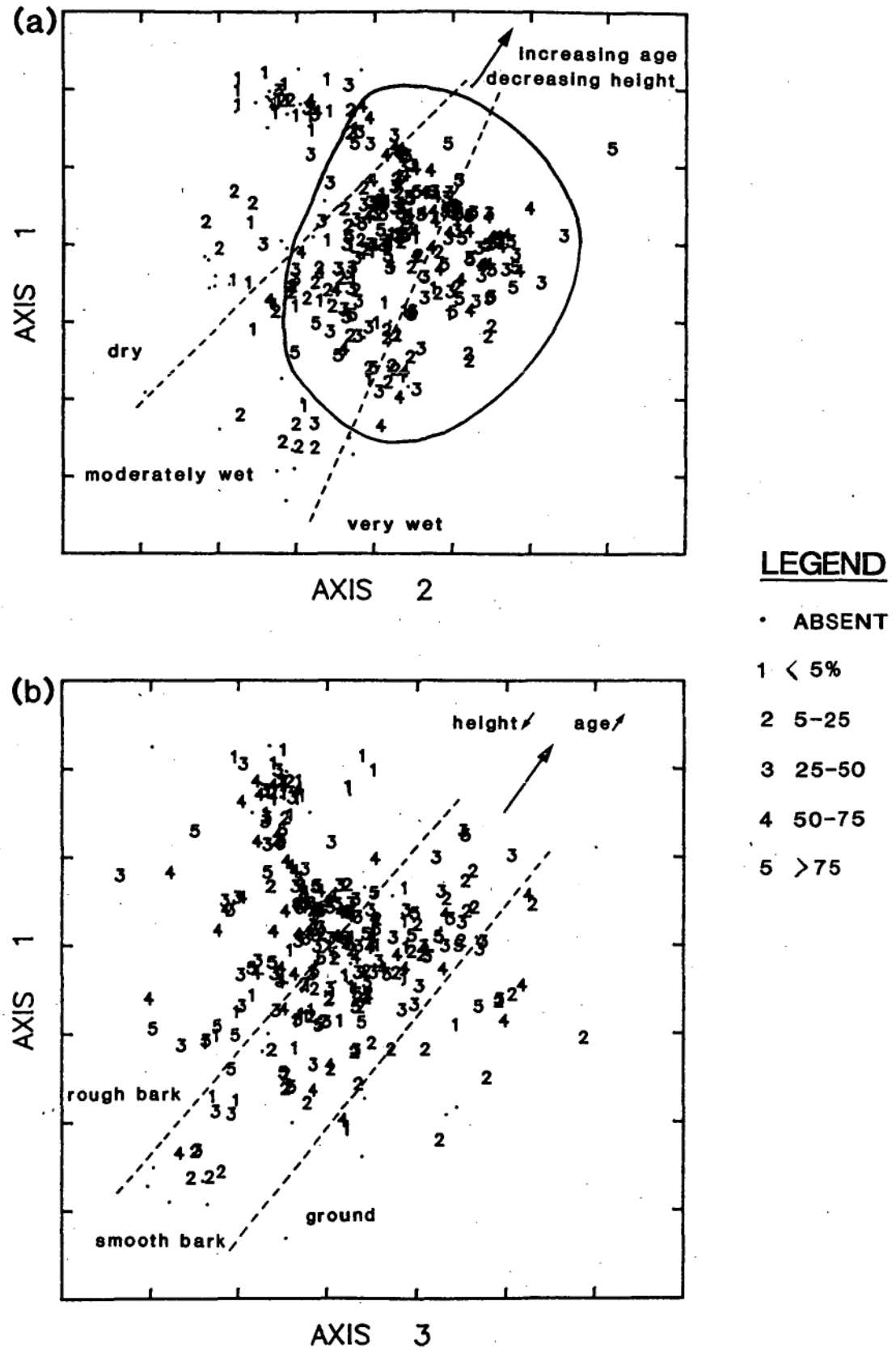



Figure 20. Distribution of "COVER OF BRYOPHYTES" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of high percentage cover are indicated.

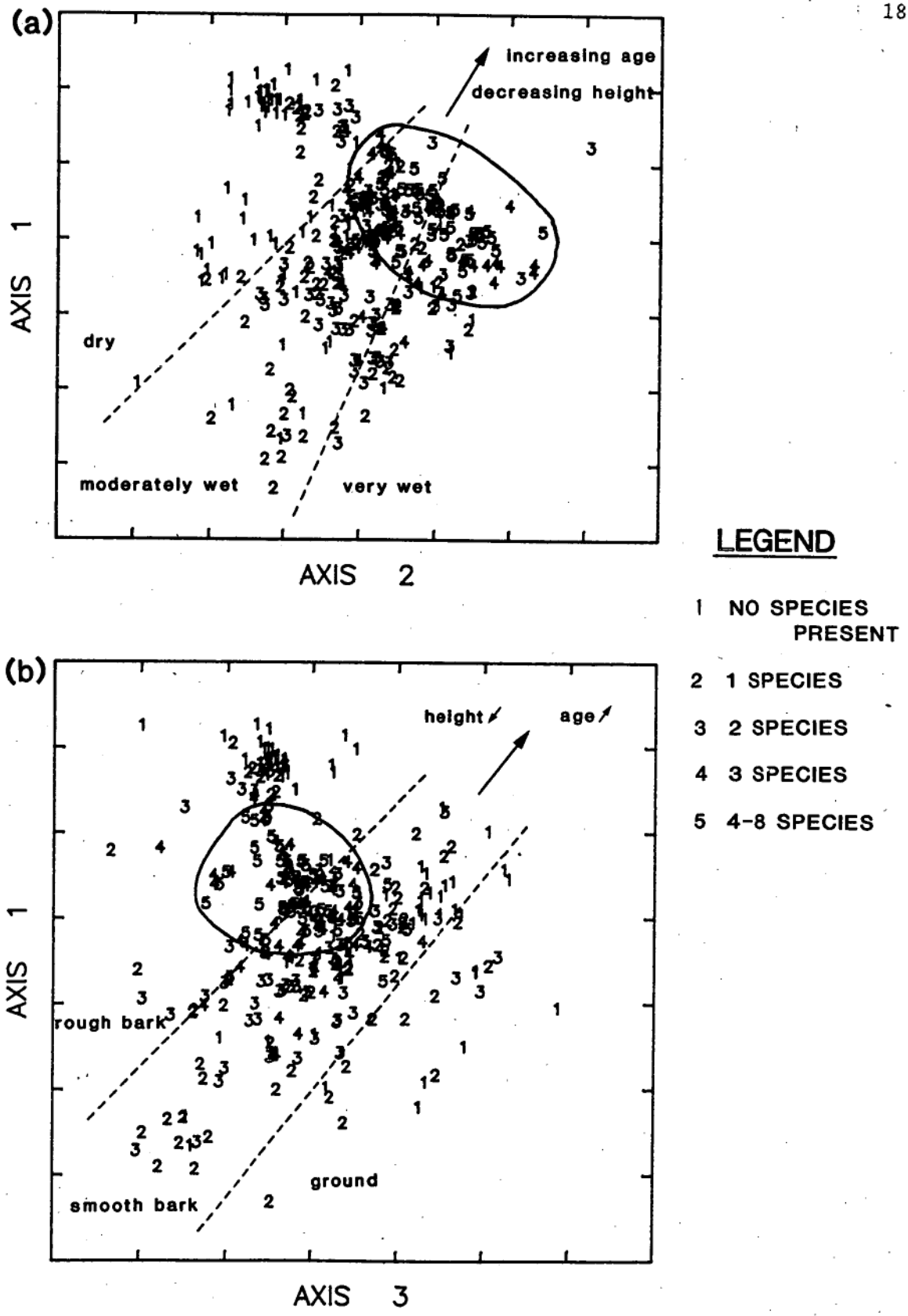



Figure 21. Distribution of "DIVERSITY OF FRUTICOSE LICHENS" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of high diversity are indicated.

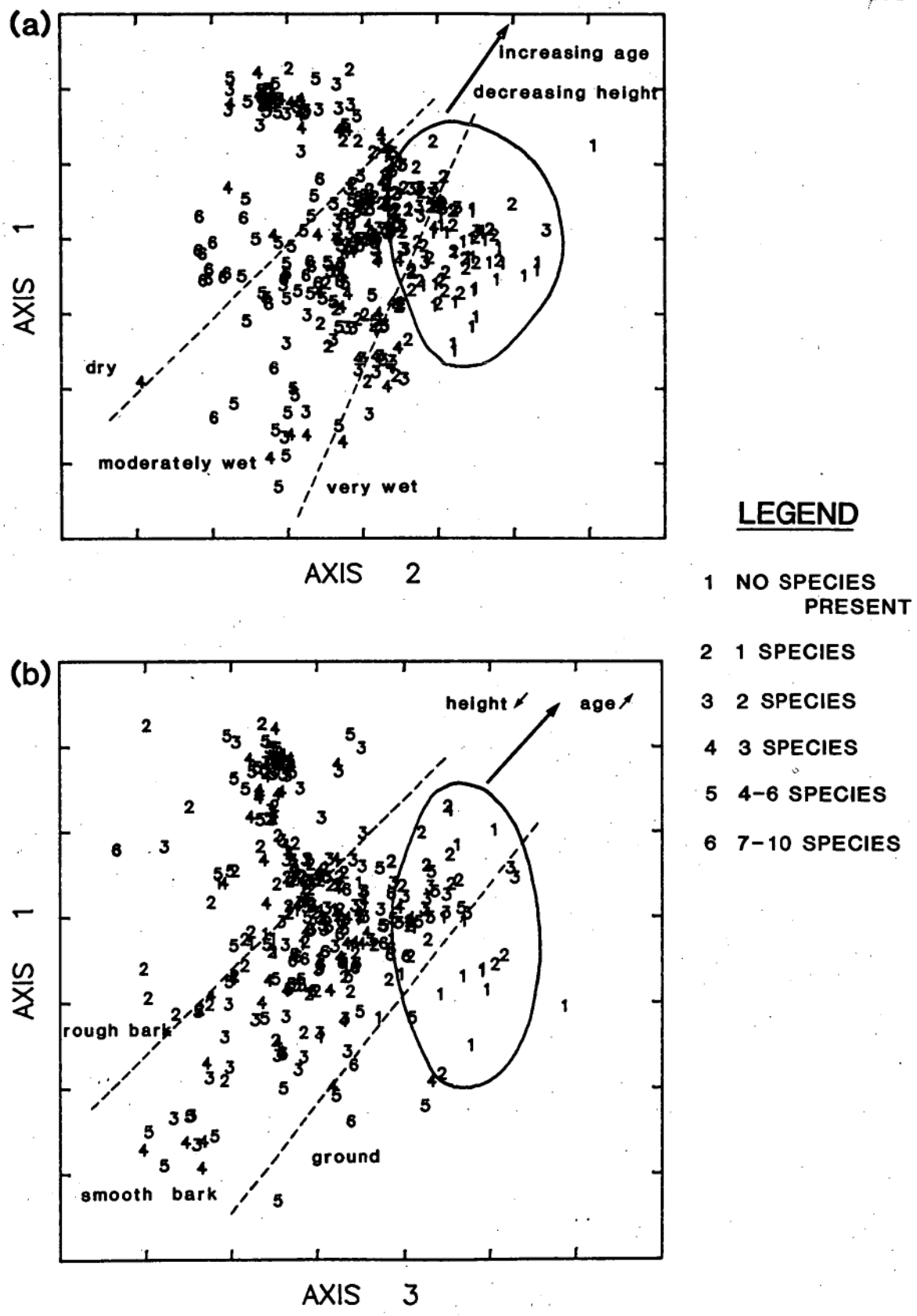



Figure 22. Distribution of "DIVERSITY OF FOLIOSE LICHENS" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of minimum diversity are indicated.

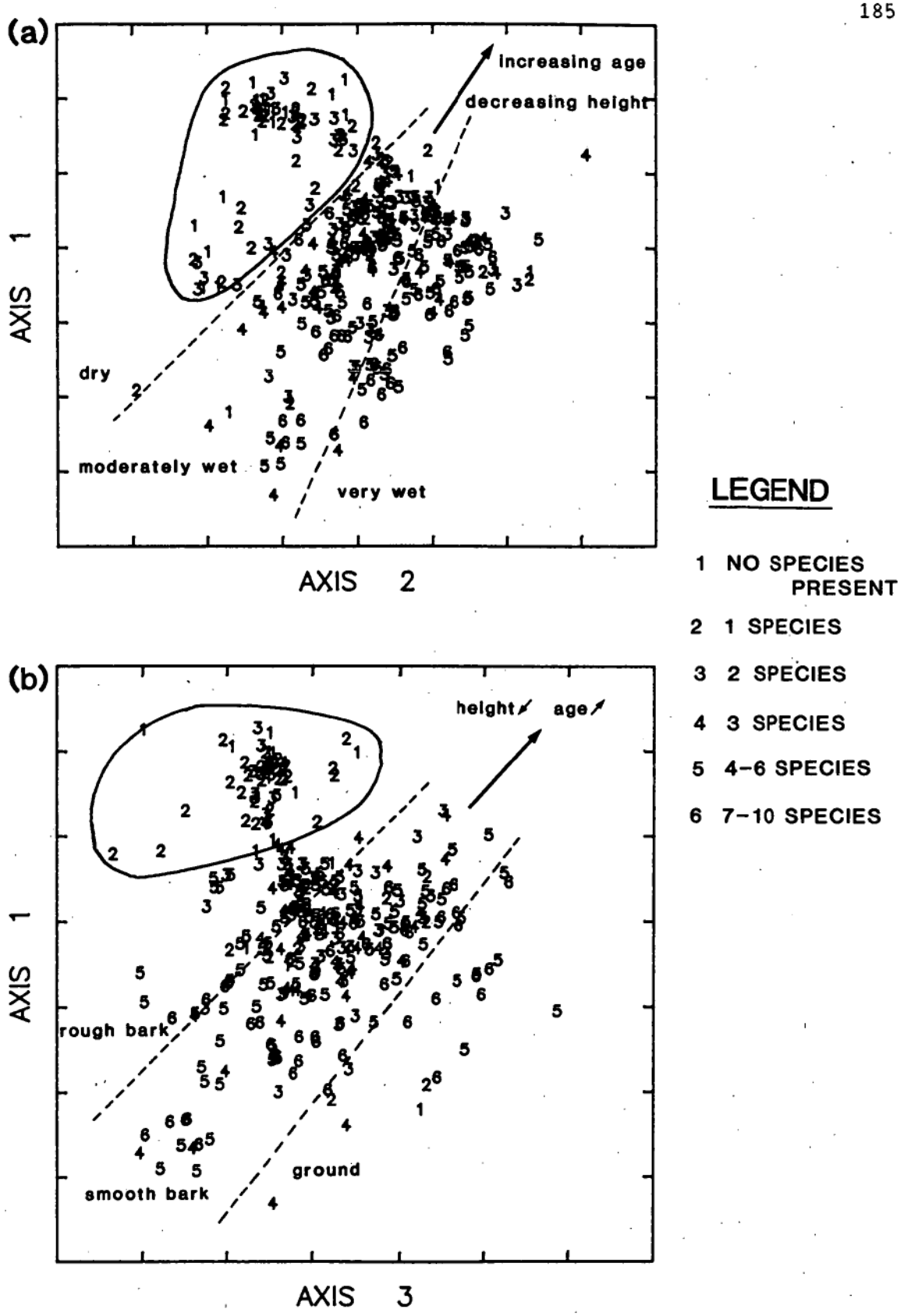



Figure 23. Distribution of "DIVERSITY OF CRUSTOSE LICHENS" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of minimum diversity are indicated.

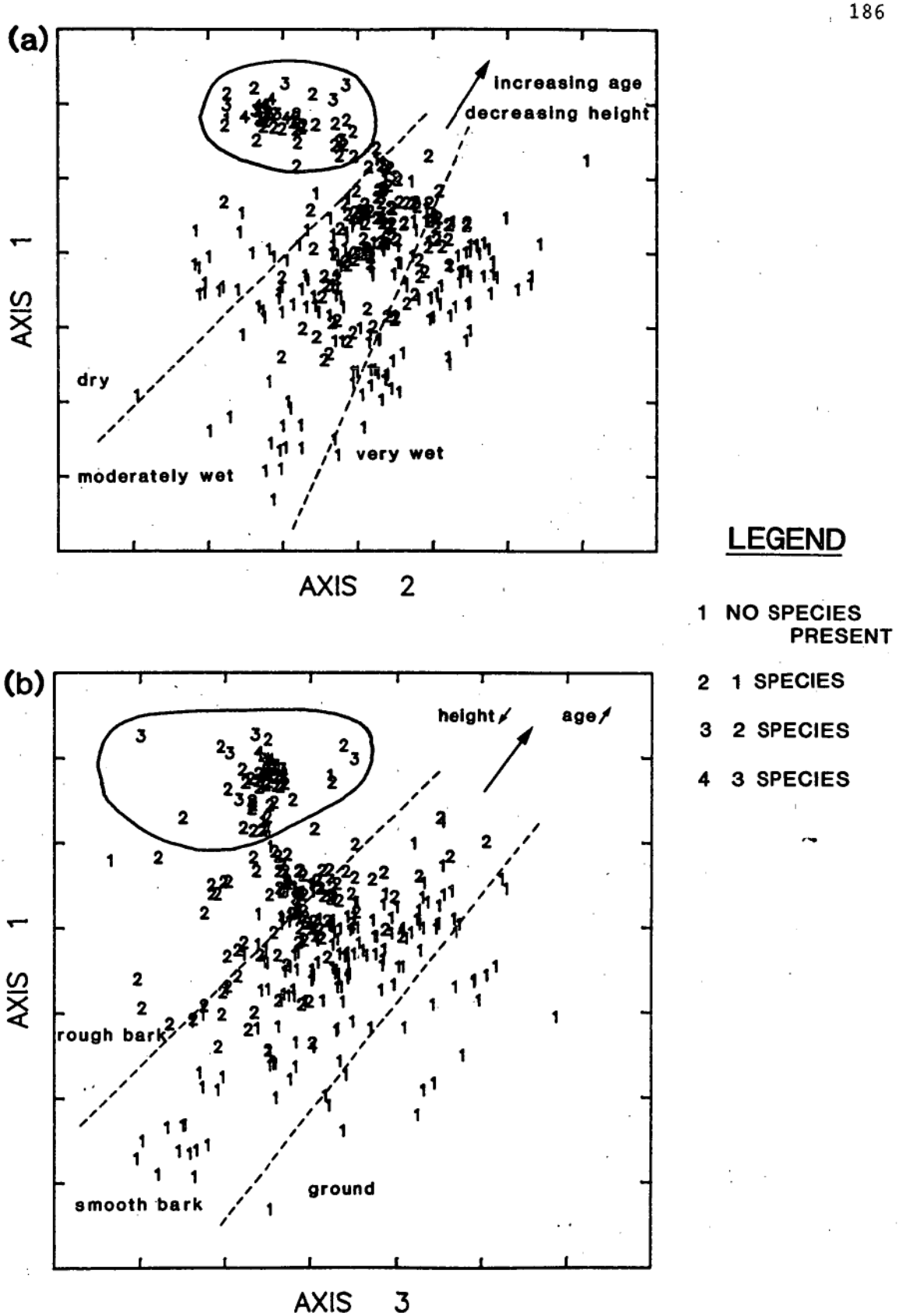



Figure 24. Distribution of "DIVERSITY OF LEPROSE LICHENS" within the configuration of quadrats defined by (a) axes 1 and 2, and (b) axes 1 and 3 of the NMDS ordination. Regions of high diversity are indicated.

eliminated by decortication or competition with fruticose lichens and bryophytes.

The distribution of the diversity of crustose lichens is illustrated in Figure 23. Like foliose lichens, crustose lichens occupy space exclusively and the regions of low diversity of these two groups are mutually exclusive (compare Figures 22 and 23). Crustose lichens are abundant on dry, rough bark but their diversity is minimum in very wet, basal habitats where they are outcompeted by bryophytes or macrolichens. They are well developed along the entire height-age gradient (gradient 1) although they are typically more conspicuous on younger wood due to their predominance in the role of pioneers.

The distribution of leprose lichens is illustrated in Figure 24. Leprose lichens constitute a small, specialised group of species of which only Lepraria incana is widespread. The remainder have very narrow distribution ranges and are mainly confined to very rough, dry bark in basal habitats. Here the leprose habit aids in repelling surface water and so complements the very dry environment.

## 3. Concluding remarks

The indirect gradient analysis has demonstrated the presence of three major environmental gradients in the epiphytic lichen vegetation. These include a height-age gradient, a moisture gradient and a substrate gradient. The relationships between the lichen communities within this scheme, and the optimum habitats for bryophytes and particular lichen growth habits have also been illustrated. The results also lend powerful support to the scheme of inter-relationships between the communities as postulated in Figure 12 by substantiating the proposed order of communities in the succession and the identity of the major environmental parameters which control their distribution. The investigation has demonstrated that ordination is an invaluable tool in the role of "trend-seeking". It is also extremely useful in illustrating assertions which are based primarily on field observations. Such assertions may be more readily acceptable if evidence for them can be derived by some "less subjective" strategy and ordination provides a means to that end.

**Summary**

The study of the lichen communities in the rainforest at Little Fisher River is the first of its kind in Tasmania. Although the study is incomplete, it forms a basis for further work with respect to both the communities described and the methods used. Some of the results are summarised below.

(a) 11 epiphytic lichen communities are recognised and described from rainforest at Little Fisher River, using the traditional, intuitive phytosociological technique of tabular comparison. One of the communities can be further subdivided into two substrate-specific facies. Supporting evidence for the classification is provided by reclassifying the data using a numerical technique.

(b) Apart from relatively minor compositional details, the communities are widespread and typical of a wide range of rainforest vegetation in Tasmania.

(c) Several additional lichen communities at the study site, i.e. those on the forest floor and on decomposing eucalypt wood, are considered adventive from neighbouring non-rainforest vegetation.

(d) A comparison of the results of the phytosociological and numerical classifications illustrates some of the relative merits of the two approaches. Both methods have advantages but the best result is derived from their integration. However, the phytosociological approach is considered more fundamental because much of its basic groundwork is necessary to adequately interpret the numerical results.

(e) Ordination techniques provide a useful method of illustrating ecological trends and confirming field observations. Three environmental gradients are of particular importance in determining the epiphytic lichen flora:

(i) an age of substrate-height above ground gradient which is also involved in vertical zonation,

(ii) a moisture gradient, and

(iii) a substrate gradient.

These gradients also incorporate the specific effects of the species of the host, and the inclination of the substrate. Aspect does not appear to be important.

(f) Ecological centres of distribution for bryophytes and each of the lichen growth habit groups are also illustrated by ordination. These show that bryophytes attain their maximum cover in the wettest habitats. Fruticose lichens are most diverse on old bark in wet basal habitats. Their maximum diversity is within the region of highest bryophyte cover, demonstrating the ability of these two groups to coexist. The diversity of foliose lichens is minimum on dry or rough bark whereas the diversity of crustose lichens is high in these habitats. Leprose lichens have a generally narrow centre of distribution on rough, dry bark in basal habitats.

# IV CONCLUSION

This study presents a detailed account of the composition and character of the Tasmanian rainforest lichen flora. Tasmania represents a major centre of the world distribution of cool temperate rainforest, as well as the site of its best development in Australia. Despite this, the cryptogamic component of the vegetation has received little attention and, before the present study commenced, the Tasmanian rainforest lichen flora was virtually unknown.

Two hundred and eight lichens, comprising 128 macrolichens and 80 crustose species, are reported from cool temperate rainforest in Tasmania. Whilst the inventory of macrolichens is considered nearly complete, the crustose lichens remain poorly known and this study has encompassed only the most common or distinctive species. With further work, their number can be expected to double at least. The majority of the rainforest lichens are epiphytic and fewer than 3% are obligately saxicolous or terricolous species.

The major phytogeographical elements represented are the "austral cool temperate", "Australian" and "cosmopolitan" elements. The first element accounts for approximately 60% of the species, including the dominant and most diverse genera, Sphaerophorus, Pseudocyphellaria, Psoroma and Menegazzia. The Tasmanian rainforest lichen flora displays closest affinities to that found in analogous forests in New Zealand, and approximately 76% of the Tasmanian species are common to both regions. Fifty-six percent of the lichens are shared with Australia (mainly Victoria) and c. 20% with South America. Only c. 5% of the flora is endemic. However, these estimates are likely to change as additional data, particularly from forests outside Tasmania, become available.

Few lichens recorded from rainforest are restricted to this vegetation. The chief factor controlling their distribution in Tasmania is rainfall, and the majority of the species occur in a range of vegetation types, roughly within the 1600 mm/year isohyet. Some of these vegetation types are pre-rainforest seral stages whilst some are considered to be derived from degraded rainforest. However, despite the widespread nature of so many of its constituent species, the rainforest flora is very distinctive, particularly in the presence of characteristic associations such as those which are restricted to very old trees. Moreover, many widespread species clearly attain their maximum development within rainforest.

Eleven epiphytic lichen communities are described from a detailed study in the Little Fisher Valley and, apart from minor compositional details, these are widespread in many Tasmanian rainforests. However, formal application of latinised names is not undertaken pending further work to assess the variability of the communities across a wider range of rainforest vegetation.

A system of inter-relationships between the communities is proposed based on the combined influences of several environmental parameters and succession. The chief factors affecting lichen distribution within rainforest are the availability of light and moisture, and the physical characteristics of the substrate. Higher plant floristics of the forest also influence the lichen flora, but their effects can mostly be interpreted in terms of light and substrate characteristics. Hence the influence of the forest vegetation depends on the types of substrates it contains (smooth, rough or fibrous barks; old or young trees) and on the penetrability to light of each stratum in the forest. This is mainly determined by the leaf size and branching pattern of the trees and shrubs.

A major environmental gradient involving the components of light and substrate age occurs vertically in the forest. Thus the oldest, shadiest substrates are nearest the forest floor and the youngest, most exposed substrates are in the canopy. The lichen flora displays marked compositional changes along this gradient with individual species and communities being adapted to particular habitats and regions. Light appears to be particularly important and the interior of many rainforest communities is apparently too shaded to support well-developed or very diverse lichen floras. Shadiest, wettest habitats are often dominated by bryophytes and consequently many of the associated lichens are fruticose and form tufts which can project through the thick mossy pad. As bryophytes decrease in importance, lichens, especially foliose and crustose species, become more abundant and, in the most exposed habitats, they are dominant, particularly bright or pale coloured species which are presumably adapted to reflecting light. The vertical zonation of rainforest lichens is modified by the characteristics of the host tree and the structure of the forest. Thus trees which are overtopped, shaded or have a very dense canopy may not develop the full suite of canopy or upper trunk communities. Conversely, in very open, well-lit forests,

there is a downwards shift of lichen zones and the most basal, shade-loving communities may be eliminated.

The texture, stability and moisture-holding capability of the substrate are responsible for many lichen distribution patterns. Foliose lichens predominate on smooth bark whereas bryophytes and fruticose lichens occur on rough bark. Crustose lichens are widespread but are outcompeted by bryophytes and macrolichens in some habitats. The age of the substrate is also important, particularly on those tree species which undergo a change in bark morphology from young, smooth bark to old dry bark. This change is often associated with massive decortication which means that epiphytes in some habitats must be continually replaced. The effect occurs on Nothofagus cunninghamii and is partly responsible for this tree supporting the most diverse epiphytic lichen flora of all the Tasmanian rainforest trees.

The importance of moisture availability is most apparent on very old trees which can develop marked wet/dry zones related to their angle and direction of lean. Wet sides are favoured by bryophytes and macrolichens whereas dry sides are mostly colonised by leprose and crustose lichens. It is interesting to note that aspect (with respect to compass bearing) has no apparent impact on the development of wet and dry habitats.

Succession between lichen communities entails not only aging of the lichen vegetation itself but also changes in the substrate (i.e. growth and development of the host tree) and changes in the surrounding forest vegetation. It is most complex along the vertical axis of the forest because superimposed upon the factors of light and moisture availability, and substrate age is the effect of successive generations of young, exposed twigs being effectively "pushed" down the light-age gradient.

Whilst no quantitative work on the factors mentioned has been undertaken, the trends described are based on extensive qualitative observations in the field and are clearly demonstrated by indirect gradient analyses. These analyses have proved invaluable in the role of trend-seeking, hypothesis-testing and in elucidating the relationships between the communities. Numerical methods have also provided good supporting evidence for the classification of lichen communities which was developed primarily by intuitive phytosociological techniques.

The study reported in this thesis represents the beginning of research into the lichen flora of Tasmanian rainforest. In addition, it documents a threatened vegetation which may well disappear as the future inevitably brings increased pressure on the forests or the land they occupy. Directions for future work which will build upon the basic framework established here are unlimited. Floristic surveys and taxonomy, particularly with respect to the crustose lichens, probably remain the most important areas for attention. There is also a definite urgency to catalogue the flora before parts of it are eradicated. For example, some of the forests studied in the present project no longer exist. Major environmental influences on the rainforest lichen flora have been identified or inferred in the present study and there is considerable scope for experimental work regarding the physiological ecology of the constituent species. The role of lichens in the nutrient balance of the forest is also important, especially given that 48% of the macrolichens contain cyanobacteria either as their main photobiont or in cephalodia. As indicators of forest microhabitats, lichens can also provide insights into forest history and structure. Studies on the rainforest lichen flora are not only of academic interest but they contribute to a better knowledge of the entire ecosystem and add to the body of evidence supporting the conservation of rainforest in Tasmania.

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# APPENDICES

# APPENDIX 1

## THE TASMANIAN RAINFOREST LICHEN FLORA

### Introduction

As outlined in the "Introduction", the Tasmanian lichen flora was relatively poorly known prior to this study and information could be obtained only from widely scattered sources. Most studies on the flora had been undertaken in the 19th Century and required considerable updating with respect to nomenclature and numbers of species. Furthermore, the relevant type specimens were held mainly in European herbaria. Thus a major aspect of the present study was to become acquainted with the relevant lichen species, an essential prerequisite for any ecological project.

This appendix presents the results of background investigations into the Tasmanian rainforest lichen flora and lists all the species recorded and identified during the project. 208 species, comprising 128 macrolichens and 80 crustose species, are treated.

The aim is to briefly outline the diagnostic features of each species, its distribution and ecology in Tasmania, and to record synonyms from the literature on Tasmanian lichens [mainly from Wetmore (1963) and Bratt and Cashin (1975, 1976)]. Notes on world distribution (derived from literature), as well as references to published sources which give complete descriptions of the species are also provided where available. The appendix is not intended as a Lichen Flora for Tasmanian rainforest but rather, it provides a thumb-nail sketch of each species. However, the amount of detail with which each species is treated varies considerably, depending on how well it is documented elsewhere. For example, descriptions of most of the macrolichens are now readily accessible in the newly published Flora of New Zealand (Galloway 1985). Moreover, their essential characters are embodied in the "Key" (p. 33) to which frequent reference is made. These characters are not reiterated here, although some supplementary data which may aid in their recognition is included where relevant. In contrast, undescribed taxa or those whose exact identity remains in some doubt are treated in more detail and, in some cases, completed descriptions are presented. This mainly involves the crustose genera which as a group require considerably

more study. Many crustose species are identified only to genera with very broad limits, e.g. Lecidea, Catillaria or Bacidia, and their systematic position is likely to change as more data become available. Hence there is no standard format for the presentation of the information and each species is treated on its merits.

During the course of this project, considerable assistance with lichen identifications was received from several specialists (see Acknowledgements) and in this regard I am particularly grateful for the assistance of Mr. P.W. James and Dr. A. Vězda. Whilst a considerable amount of checking remains to be done, the data presented here represent a considerable advance on previous documentation of the flora. It is hoped that these results can serve as the foundation of a future Lichen Flora for Tasmanian rainforest.

**The species**

1. Arthonia cineropruinosa Schaer. sens.lat.

Thallus thin, crustose or ± byssoid, pale grey. Apothecia to 1.5 mm diam., irregularly roundish, sometimes shallowly lobed, densely grey pruinose, often with a thin white border. Spores hyaline to pale grey, clavate, 12-16 x 5-6 µm, 3-septate with the end cell enlarged.

The species is a new record for Tasmania. It occurs on the very dry fissured bark of old Nothofagus cunninghamii trunks where it is usually associated with Lecanactis abietina, Sagenidium molle, Lepraria incana and species of Micarea and the Caliciales.

The species of Arthonia with grey pruinose apothecia constitute a complex group. On the basis of the discussion of British species (Coppins and James 1978), Tasmanian material appears to combine characters of both A. cinereopruinosa s. str. from Europe and the British taxon, A. cinereopruinosa auct. angl., described by those authors (loc. cit.). The Tasmanian species accords with the former in its rounded apothecia which have a reddish brown lower exciple, K+ olive green. However, like the British taxon, the apothecia are only c. 100 µm thick (or less) in median section. The chemical constituents of the Tasmanian material have not been identified but they do not include psoromic acid, present in the type of A. cinereopruinosa s. str. (Coppins and James op. cit.). The ecology of the Tasmanian species is analogous to that of its British counterpart

which occurs on the driest sides of ancient Quercus (Coppins and James op. cit.). The Tasmanian material has been identified by Dr. A. Vězda.

2. Arthonia sp.1 (aff. A. pinastri Anzi)

Thallus crustose, whitish-grey, thin and evanescent. Apothecia to 0.3 mm diam, roundish, black. Spores pale grey, turning olivaceous with age, clavate, (8-)10-15 x 4-5 µm, (2-)3 septate with the end cell enlarged. Internal parts of apothecium K- or K+ olive.

The species is common and widespread in Tasmanian rainforest, chiefly on the dry fissured bark of mature Nothofagus cunninghamii. It often occurs where decortication is most active, colonising the newly exposed, temporarily smooth bark which is revealed when plates of old bark are shed. The species is commonly in poor condition with eroded apothecia but there are no confusing species which occur in similar habitats.

3. Arthonia sp.2

Thallus crustose, thin, greyish to dull rusty brown. Apothecia c. 0.2-0.3(-0.5) mm diam., roundish, black. Spores grey, ellipsoid to ovate, sometimes slightly curved, 3-septate, 29-40 x 12-16 µm. No reactions in K.

The species has been recorded from the lower parts of smooth barked trunks and branches of various phorophytes (including Atherosperma, Pittosporum and Nothofagus. It is apparently rare but probably overlooked.

4. Arthothelium sp.1

Thallus crustose, variable in colour, grey to olivaceous or reddish brown. Apothecia mostly to 1 mm (rarely 2 mm) diam., irregularly roundish, black or dark brown. Spores faint grey, clavate, often curved, 22-35(-40) x 7-12(-14) µm, with 4-6(-9) transverse septa and 0-2(-4) longtitudinal septa (across the central cells only). Internal parts of apothecia K+ olive-green.

This variable species is the most common arthonioid lichen in Tasmanian rainforest. It occurs on various phorophytes with smooth bark and is a common pioneer species on young trunks within the forest.

5. Arthothelium ilicinum (Taylor) P. James

Thallus crustose, pale grey. Apothecia to 0.5 mm diam., roundish, black to dark brown. Spores hyaline, clavate, often ± curved, 26-32 x 9-13 µm, with 4-5(-6) transverse septa and an enlarged terminal cell.

The species is similar to the preceding lichen but differs in its smaller apothecia and the absence of any longtitudinal septa in the spores. Moreover, the K+ olive reaction of the internal parts of the apothecium is absent or weak. A. ilicinum is apparently uncommon in Tasmania and has been collected mainly from smooth, shaded Atherosperma trunks. The species is a new record for Tasmania and was previously known only from the British Isles (Poelt 1969). Tasmanian material has been determined by Dr. A. Vězda and Mr. P. James. Arthonia multiformis Shirley, described from Mt. Wellington, Tasmania (Shirley 1894) (BRI 351372), appears to be identical with Arthothelium ilicinum.

6. Arthothelium sp.2

Thallus crustose, thin, pale brownish grey. Apothecia c. 0.3 mm diam., round to oblong, black to dark brown. Spores hyaline, ellipsoid, 38-43 x 18-20 µm, muriform throughout. Internal parts of apothecium K+ bright pink.

The species is known from a single collection from the young branches of Andopetalum in thamnic rainforest in south-western Tasmania where it was associated with Coccotrema cucurbitula and Megalospora lopadioides.

7. "Asteristion" lamelliferum A. Vězda nom. provis.

Thallus crustose, pale greenish grey, thick or thin and evanescent. Photobiont ?Trentepohlia. Apothecia to 2.5 mm diam. Thalline margin thick, exfoliating, fissured, pale grey. Disc mostly widely exposed, pale pink-brown to brown, sometimes ± greyish pruinose, plane to undulate. Paraphyses simple. Spores hyaline, 8/ascus, muriform, 45-70 x 10-19 µm, with c. 14 transverse and 3 longitudinal thick septa.

The species is found in most rainforest communities in Tasmania although it is often rare. It occurs in moist, shaded habitats, usually amongst bryophytes, on rough or smooth bark, on wood, peaty

soil or, rarely, on rocks. The moist, fissured trunks of mature Nothofagus trees are common substrates and here the species is often associated with Thelotrema subdenticulatum and Sphaerophorus spp. Outside of rainforest, the species is known from fire-protected, sheltered rock crevices in alpine heath in south-western Tasmania. "Asteristion" lamelliferum is widespread in the western half of Tasmania with outlying populations in high altitude rainforests in the north-eastern highlands. It is also known from New Zealand (A. Vězda pers. comm.).

"Asteristion" lamelliferum is allied to both Ramonia and the Thelotrema platycarpum group but requires the erection of a new genus (A. Vězda pers. comm.). A second, related, endemic species occurs on the leaves of Astelia alpina (Liliaceae) in alpine moorland in Tasmania.

8. Austroblastenia pauciseptata (Shirley) Sipman
= Lopadium pauciseptatum (Shirley) Zahlbr.

Thallus crustose, thick, whitish grey, with rugulose warts which burst and develop into soralia. Apothecia to 3.5 mm diam. Disc flat or slightly convex, reddish brown. Margin thin, outer surface pale fawn brown. Spores 4-8/ascus, 33-40 x 14-20 µm, 4-celled. Septa thick, with a central pore.
Chemistry: pannarin, zeorin

A complete description of the species is given by Sipman (1983). A. pauciseptata is widespread in high rainfall areas in Tasmania. It occurs on smooth bark in open habitats such as forest clearings, open woodlands or on the upper parts of trees. It is also known from New Zealand.

9. Bacidia buchananii (Stirton) Hellbom
= Gomphillus baeomyceoides Wilson

Thallus granular, dull green. Apothecia to 1.5 mm diam., brown, immarginate, ± globose, constricted at the base and appearing subpedicellate. Spores hyaline, filiform, 140-170 x 2-4 µm, with more than 30 septa and rounded ends.

See Galloway (1985) for a complete description. Although widespread, the species is not common in Tasmanian rainforest where

it occurs in deep shade over bryophytes on bark or, more rarely, rocks. B. buchananii is also known from Australia and New Zealand.

10. Bacidia weymouthii (Shirley) Zahlbr.

Thallus crustose, thin, whitish-grey, cream or brownish-green, bordered by a black prothallus. Apothecia lecideine, to 0.8 mm diam., black, shiny, with a flexuose margin, occasionally supporting clusters of superficial smaller apothecia. Disc plane, becoming convex with age. Epithecium black, becoming ± blackish-green in K. Exciple black, opaque. Hymenium and hypothecium colourless to pale or dark brown, K-. Paraphyses delicate, c. 2 µm wide, separating easily in K, with blackened tips. Asci clavate, 48-65 x 12-17 µm. Spores hyaline, curved, acicular, somewhat broader at one end, with ± acuminate apices, 41-52 x 3.5-6(-7) µm, spiralled in the ascus, with 4-6 indistinct septa.

Chemistry: no substances detected (?trace atranorin)

B. weymouthii is widespread in callidendrous rainforest where it is a pioneer of smooth barked trees, particularly Atherosperma. Commonly associated lichens include Thelotrema lepadinum, Coccotrema cucurbitula, Phlyctella subuncinata and species of Arthothelium. The species is endemic to Tasmania but could be expected to also occur in Victoria where similar callidendrous rainforest communities occur. Although Shirley (1894) states that the spores of this species are 26-30 x 2-2.5 µm, an examination of the type specimen (MEL 7048) revealed they were in fact much larger.

11. Bacidia sp.1

Thallus dull green, granular-crustose, dispersed over a black prothallus. Apothecia lecideine, black, to 0.6 mm diam., plane at first, becoming convex, immarginate. Internal parts of apothecia intensely darkened, K- or K+ faintly purplish brown. Exciple and hypothecium dark brown to black, opaque. Epithecium blackish to bluish-black. Hymenium similarly coloured, often paler, c. 70-80 µm thick, paraphyses conglutinated. Spores hyaline, acicular, spiralled in the ascus, 60-75 x 1.5-2 µm, indistinctly multi-septate.

The species is common in shaded habitats in rainforest, particularly in thamnic communities where it occurs on trunks and low twigs of Andopetalum, Eucryphia lucida, Trochocarpa gunnii and other

hosts. It is found over mosses or directly on smooth bark. Some specimens are associated with an unidentified, stalked parasite resembling a member of the Caliciales. Bacidia sp.1 shows some affinities to B. muscorum in the Northern Hemisphere (P. James pers. comm.).

12. Bacidia sp.2

Thallus crustose, pale grey to glaucous grey, thin to rather thick and aereolate. Apothecia lecideine, immarginate, to 1 mm diam., whitish to pale fawn brown, plane at first but soon becoming convex. Epithecium colourless. Hymenium colourless, c. 120 µm thick. Hypothecium colourless to yellow-brown, intensifying yellow in K. Spores hyaline, acicular, curved, somewhat broader and blunter at one end, tapering to a point at the other, 43-80 x 2-3 µm, with 6-9 septa.

Bacidia sp.2 is a pioneer species of Atherosperma trunks, known from two collections from northern Tasmania but probably overlooked elsewhere. The species is macroscopically similar to Catillaria sp.1 (see below).

13. Bactrospora sp.

Thallus crustose, thick, granular-leprose or thin and scurfy, greyish white or cream. Apothecia to 0.5 mm diam., black to blackish brown, convex, almost subglobose, soon immarginate, usually with the disc rough and uneven. Epithecium pale brown, K- or K+ green-grey. Hymenium and hypothecium colourless. Paraphyses very distinct, separating easily, branched. Spores hyaline, (4-)8/ascus, multiseptate (to c. 50 times), cylindrical, usually rounded at one end and pointed at the other, (48-)80-145 x 7-12 µm.
Chemistry: gyrophoric acid, thallus C+ red. The reaction may be barely perceptible in the thin, scurfy thalli.

The species is known from several rainforest localities, mostly in north-western Tasmania, where it occurs on moderately dry, rough or smooth bark. Fertile material is extremely rare and in its typical vegetative form, the species resembles the granular, leprose unknown taxon, species A. However, it can be distinguished by the C+ red reaction.

14. Bactrospora dryina (Ach.) Massal.

Thallus crustose, thin and scurfy, never granular, greyish white or cream. Apothecia to 0.3 mm diam., blackish brown, ± immersed when young, convex, immarginate, with the disc remaining ± smooth. Spores hyaline, ± acicular, usually broader and rounded at one end, 36-58 x 2.5-3.5 µm, rarely more than 20-locular.
Chemistry: thallus C-, K-, Pd-, KC-

B. dryina is rather similar to the preceding species, Bactrospora sp., but differs in its non-granular, C- thallus, smaller apothecia and smaller, acicular spores with fewer septa. It is known from the dry, rough bark of mature Nothofagus cunninghamii in rainforest in the Arthur River catchment, north-western Tasmania. Despite the abundance of apothecia on the specimens collected, few spores could be found and the majority of asci were empty (in contrast to the material of Bactrospora sp.). The species is a new record for Tasmania and the Southern Hemisphere. Tasmanian specimens have been determined by Dr. A. Vězda.

15. Baeomyces fungoides (Sw.) Ach.

See Galloway (1980a) for a full description and p.38, couplet 32, for diagnostic features. The species is very common and widespread in open areas over moist soil and stones, particularly in disturbed habitats such as roadsides. It is uncommon in rainforest except at the forest margins or on the soil of uprooted trees in clearings. Commonly associated species include Placopsis spp., Stereocaulon ramulosum and the moss, Polytrichum juniperinum. The record of B. roseus from Tasmania (Wetmore 1963) almost certainly refers to B. fungoides. The species also occurs in Australia, New Zealand, the West Indies, and Central and South America (Galloway op. cit.).

16. Baeomyces heteromorphus Nyl. ex Church. Bab. & Mitten

For a full description see Galloway (1980a). Diagnostic features are given on p.38, couplet 32. The habitat and distribution of the species is similar to that of B. fungoides. B. heteromorphus is widespread in New Zealand and Australia.

17. Catillaria kelica (Stirton) Zahlbr.

Thallus crustose, thin, pale greenish-grey. Apothecia to 1 mm diam., deformed roundish, immarginate, convex, golden yellow but frequently partially or entirely blackened. Epithecium with yellow-brown granules, dissolving in K (dark grey, unchanged in K in blackened apothecia). Hymenium 60-70 µm thick, interspersed with yellow granules dissolving in K. Hypothecium pale brown. Spores hyaline, 1-septate, ellipsoid, with pointed ends, 12-18 x 5-6 µm.

The species is common and widespread at low levels in rainforest on trees with smooth bark, particularly Atherosperma and Cenarrhenes. It is readily recognised by its mustard-yellow, immarginate fruits. Specimens where the apothecia are blackened usually posses at least some apothecia where hints of the diagnostic yellow colour remain. Previously considered endemic to New Zealand (Galloway 1985), Catillaria kelica is a new record for Tasmania. A complete description is given in Galloway (op. cit.).

18. Catillaria sp.1

Thallus crustose, thin, pale greenish-grey. Apothecia lecideine, to 1.5 mm diam., milky white to very pale fawn, flat, with a ± translucent, white proper margin when young, becoming convex, immarginate and sometimes blackened with age (disc occasionally blackened from the first). Epithecium colourless to pale brown, granular, dissolving in K, c. 12 µm thick. Hymenium colourless, 40-50(-80) µm thick. Hypothecium colourless to pale brown, c. 70 µm thick. Spores hyaline, 1-septate, ellipsoid, frequently ± curved, (10-)12-18 x (4-)6-10 µm.

Catillaria sp.1 is a common and widespread pioneer species on various substrates, including hosts with smooth bark (e.g. Atherosperma) or fibrous bark (e.g. Monotoca glauca). Macroscopically, the species is similar to Bacidia sp.2 in which the thallus is usually thicker and the apothecia are convex and immarginate from the beginning and never blackened.

19. Catillaria sp.2

Thallus crustose, thin, pale bluish or greenish grey, rarely olivaceous, typically surrounded by a distinct black prothallus. Apothecia lecideine, to 1.5 mm diam., black, immarginate, adnate,

convex, deformed roundish. Epithecium bluish grey, K+ pale greenish. Hymenium similarly coloured (or occasionally with a purple tinge, turning colourless in K), 60-100 µm thick. Hypothecium pale brown, occasionally reddish brown, 50-100 µm thick. Spores hyaline, 1-septate, narrow ellipsoid, with rounded ends, 12-18 x 3-7 µm.

Catillaria sp.2 is a common and widespread but very variable species, occurring on smooth bark in deeep shade. Typical phorophytes include Atherosperma and Tasmannia. The lichen is usually associated with Thelotrema lepadinum and species of Catillaria and Arthothelium.

20. Catillaria sp.3

Thallus crustose, thin, scurfy, whitish grey. Apothecia to 0.5 mm diam., pale fawn brown, becoming brown with age, strongly convex and immarginate. Internal parts of apothecium colourless, K-. Exciple of radiating hyphae in a gelatinised matrix. Epithecium hyaline, non-granular. Paraphyses sparingly branched, anastamosing, c. 1.2-1.5 µm thick. Spores hyaline, narrow-ellipsoid, 1-septate (sometimes simple), 7-16 x 2-2.5(-4.5) µm.

The species has been recorded from very dry, mature trunks of Nothofagus cunninghamii. Tasmanian material has been examined by Dr. B.J. Coppins who observes that the species has some affinities with the European taxon, C. chlorotiza (Nyl.) P. James, although it lacks pycnidia.

21. Catillaria sp.4

Thallus granular-leprose, whitish grey. Apothecia lecideine, to 1 mm diam., plane, with a thin, whitish proper margin at first, becoming convex and immarginate with age. Disc pale orange-pink, lightly whitish pruinose when young. Exciple and epithecium pale straw coloured, with minute granular inclusions clearing in K. Hymenium colourless, paraphyses branched, c. 1.5 µm thick, with apices irregularly swollen to 4 µm. Spores hyaline, 0-1 septate, narrow ellipsoid, 7.5-12 x 2.5-4 µm.

The species is known from a single collection from dry mature trunks of Nothofagus cunninghamii at Little Fisher River, where it was associated with Lecanactis abietina and species of Caliciales. It is distinguished from Catillaria sp.3 by its better developed

granular thallus and by its granular epithecium and exciple. The species has been provisionally identified by Dr. B.J. Coppins.

22. Catinaria pulverea (Borrer) Vězda & Poelt

Thallus crustose, ± granular, pale glaucous green to grey, sorediate. Apothecia lecideine, to 1.8 mm diam. Disc concave at first, becoming flat or convex with age, dark brown to black, with a thin, pale, ± translucent proper margin often disappearing with age. Spores hyaline, 1-septate, ellipsoid, 15-21(-25) x 5-9 µm.
Chemistry: fumarprotocetraric acid, atranorin, zeorin (thallus K+ yellow, Pd+ red)

C. pulverea is uncommon in Tasmania and is found mostly on mature trunks in clearings in high altitude callidendrous rainforest. The species is variable and some specimens are virtually esorediate. However, the dark fruits with a pale margin are diagnostic. The species is a new record for Tasmania and is also known from Europe and New Zealand. Further data are given by Galloway (1985) and Poelt and Vězda (1981).

23. Catinaria (Megalaria) sp.

Thallus crustose, grey, very thin, evanescent. Apothecia lecideine, to 2 mm diam. Disc black (sometimes rather pallid when very young), flat, becoming convex with age. Margin concolorous with disc, thick at first but ± absent in older apothecia. Epithecium dark brown-black, K+ greenish or pale brown (often weakly). Hymenium pale straw or colourless, 50-75 µm thick. Hypothecium colourless throughout or pale brown in the upper part, 90-150 µm thick. Spores hyaline, 1-septate, 17-24 x 9-14 µm.

Catinaria sp. is common in high altitude callidendrous forest where it is a pioneer species on low twigs and young trunks.

24. Cetraria chlorophylla (Willd.) Vainio
= C. scutata (Wulf.) Poetsch

Tasmanian material corresponds to that described from Britain by Duncan (1970). Diagnostic features are also given on p.52, couplet 113. The species is uncommon and mostly confined to rainforest above c. 600 m in northern and north-eastern Tasmania. It usually occurs as an epiphyte on smooth bark in clearings or in the canopy. One collection is from sandstone boulders.

25. Chaenotheca brunneola (Ach.) Mull. Arg.

Thallus granular-crustose, grey or greenish grey, often with a bluish tinge. Fruit a stalked mazaedium, spherical, 0.3-0.5 mm diam., dark brown. Stalk dark brown, slender, c. 2 mm tall. Spores simple, spherical, dark brown in the mass, 2.5-5 µm wide.

C. brunneola is the most common rainforest species of the crustose Caliciales. It occurs on the dry faces of mature, fissured Nothofagus where it is commonly associated with Lecanactis abietina and Sagenidium. Outside rainforest, it is also common on the dead leaves of Richea pandanifolia. A full description of the species is given by Tibell (1980). The species is cosmopolitan but has not been recorded previously from Tasmania. Tasmanian specimens have been identified by Dr. L. Tibell.

26. Chiodecton colensoi (Massal.) Müll. Arg.

Thallus crustose, often aereolate, pale grey to fawn brown, occasionally with a pinkish tinge. Apothecia immersed in thalline warts which are rounded, elongate or irregular, mostly c. 2 mm across, sometimes confluent. Apothecial discs minute, < 0.1 mm diam., several to many per wart, often confluent, visible as black dots or short lines on the surface of the warts. Epithecium and hypothecium dark brown, K+ dull greenish grey-black. Spores hyaline, 3-septate, acicular, often curved, with rounded ends, 36-51 x 2.5-3.5 µm.
Chemistry: no substances detected

The species is widespread but often overlooked in rainforest where it occurs mainly on trees with smooth bark, notably Anodopetalum, Atherosperma and Tasmannia. It is found in the canopy as well as in shaded, basal habitats. Shirley (1894) records another species, C. perplexum Nyl., from Tasmania (Mt. Wellington). Although

his specimen (BRI 351371) is in poor condition and no spores could be examined, it appears to correspond with C. colensoi.

27. Chrysothrix candelaris (L.) Laundon
= Lepraria candelaris (L.) Fries

Thallus leprose, diffuse and scattered or ± continuous, bright golden yellow. Apothecia unknown in Tasmanian material.

A complete description is given by Laundon (1981). The species is cosmopolitan and, in Tasmania, occurs in dry microhabitats on rocks or trees in a wide range of vegetation types. It is uncommon in rainforest where it is confined to the dry faces of mature, rough-barked Nothofagus cunninghamii. The species could occasionally be confused with Psilolechia lucida which has a paler lemon-yellow thallus and distinctive apothecia.

28. Cladia aggregata (Sw.) Nyl.
= Cladonia aggregata (Sw.) Sprengel
= C. cornicularia Laurer
= C. gorgonina (Bory) Vainio
= C. terebrata (Laurer) Flörke
= Dufourea collodes J.D. Hook. & Taylor

The species is extremely polymorphic and a full description is given by Filson (1981). Diagnostic features of the rainforest form are given on p.39, couplet 35. Various chemical strains have been reported (see Filson op. cit.) but most rainforest specimens contain barbatic and 4-O-demethylbarbatic acids. C. aggregata is widespread and common throughout Tasmania and occurs on soil, bark or wood, often amongst bryophytes. It is abundant in rainforest and ranges from deep shade to exposed habitats. The species is also known from much of the Southern Hemisphere as well as from Central America, South-East Asia and Japan.

29. Cladia schizopora (Nyl.) Nyl.

A full description of this species is given by Filson (1981). Diagnostic features are summarised on p.38, couplet 33. Unlike other species of Cladia, C. schizopora appears to have a dimorphic thallus, due to the usually complete degeneration into soredia of the sterile pseudopodetia. The chemistry of the species is variable but most specimens examined contained fumarprotocetraric acid. In Tasmania, C.

schizopora is virtually confined to Eucalyptus and other myrtaceous trees. It is widespread in sclerophyll vegetation but rare in rainforest where it is commonly associated with Lepraria incana and Cladonia squamosula. Cladia schizopora is also known from Australia, New Zealand and Chile.

30. Cladina confusa (R. Sant.) Follm. & Ahti
= C. leptoclada (des Abb.) D. Galloway

For full taxonomic details, see Ahti (1961) [as C. leptoclada] and Ahti (1984). Diagnostic features are given on p.39, couplet 36. C. confusa is widespread in the Southern Hemisphere (Ahti 1984). In Tasmanian rainforest, it is confined to high altitude callidendrous communities where it forms small cushions on mossy ground in clearings. The species is more widespread and common in sclerophyll forest, sedgeland and heaths, particularly at high altitudes. In general, specimens from very shaded habitats are more grey and contain lower concentrations of usnic acid.

Several species referable to the genus Cladina have been recorded from Tasmania by 19th Century botanists, including Cladonia alpestris, C. pycnoclada, C. rangiferina, C. impexa and C. sylvatica (see Wetmore 1963). However, the presence of only three [including C. mitis (Sanstede) Hustich and C. tasmanica (Ahti) Ahti] are confirmed by more recent collections, suggesting that the earlier records are probably misdeterminations. Of these, C. mitis is an alpine species whereas C. tasmanica is rare and known only from the type collection.

31. Cladonia chlorophaea (Flörke ex Sommerf.) Sprengel aggr.

A full description is given by Galloway (1985). Diagnostic features are summarised on p.37, couplet 29. Chemical variation in the C. chlorophaea aggr. in Australia is discussed by Archer (1983). Specimens from Tasmanian rainforest contain either fumarprotocetraric acid alone (= C. chlorophaea s. str.) or merochlorophaeic and 4-O-methyl-cryptochlorophaeic acids, with or without fumarprotocetraric acid (= C. merochlorophaea Asah.) The species is rare in rainforest and seldom develops more than 1-2 podetia, scattered amongst bryophytes. C. chlorophaea is cosmopolitan.

32. Cladonia ochrochlora Flörke

Basal squamules numerous, incised. Podetia to 40 mm tall, subulate or with minute cups, not or very sparingly branched, at best bifurcate in the upper third, with or without podetial squamules, ± corticate in the lower third, cortex becoming increasingly chinky and interspersed with farinose sorediate patches towards the tips of the podetia. Apothecia brown, rare.
Chemistry: fumarprotocetraric acid (major substance)

C. ochrochlora is common but poorly developed in rainforest and usually occurs amongst epiphytic bryophytes. Many specimens consist mainly of basal squamules with a few deformed podetia. Most Tasmanian rainforest specimens of Cladonia which contain fumarprotocetraric acid can be ascribed to this species. However, the identification of such specimens is difficult as they are very variable. In some cases, the sorediate patches may extend over the uppermost two thirds of the podetia. In general, Australian Cladoniae with this chemistry remain a problem (A. Archer pers. comm.) and additional species, e.g. C. anomaea, C. campbelliana and C. coniocraea, may also be present. Further data on these species are available in Galloway (1985) and Thomson (1968). Diagnostic features of C. ochrochlora are given on p.38, couplet 30. The species is cosmopolitan.

33. Cladonia scabriuscula (Delise) Leighton

A complete description of the species is given by Galloway (1985). Diagnostic features are listed on p.39, couplet 36. C. scabriuscula is locally common in high altitude callidendrous rainforest across northern Tasmania where it forms extensive swards on the forest floor in association with Cladina confusa and bryophytes. It is also widespread in sclerophyll vegetation. The species is similar to C. furcata which is corticate throughout and which does not occur in rainforest. C. scabriuscula is cosmopolitan.

34. Cladonia squamosula Müll. Arg.

See Galloway (1985) for a complete description and p.38, couplet 30, for diagnostic features. C. squamosula is common and widespread in most vegetation types in Tasmania and usually occurs on burnt or rotting Eucalyptus wood. Its chemistry includes thamnolic and barbatic acids, the latter occurring in the apothecia only. The species is rather similar to some forms of C. ochrochlora, a lichen

which is rarely found on Eucalyptus in rainforest and which contains fumarprotocetraric acid. C. squamosula is also known from Australia and New Zealand.

35. Cladonia subdigitata Nyl.

See Galloway (1985) for full description and p.37, couplet 28, for diagnostic features. C. subdigitata is a widespread, polymorphic species, common at subalpine or alpine altitudes on rotting wood or peat. Some individuals are grossly deformed and covered by brown outgrowths resembling juvenile apothecia. Specimens from rainforest are usually slender, simple and with narrow but well-defined cups. C. pleurota is possibly a confusing species but differs in its broader cups, the presence of farinose soredia and its chemistry (usnic acid and zeorin). C. subdigitata is also known from Australia and New Zealand.

36. Cliostomum griffithii (Sm.) Coppins

Thallus crustose to ± granular, whitish. Apothecia to 0.8 mm diam., greyish brown to black, with a thin, persistent black margin. Disc flat to convex, faintly pruinose. Epithecium pale brown, with minute granules dissolving in K. Hymenium colourless, 35-50 µm thick. Hypothecium colourless, 50-70 µm thick. Exciple pale brown, colourless in K, the inner edge K+ faint purplish. Spores hyaline, 1-septate, sometimes slightly curved, 8-14 x 2.5-4 µm. Pycnidia numerous, visible as black cylindrical spots, c. 0.1 mm wide, usually with a central white dot, outer edge K+ purplish (in squash preparations). Conidia pip-shaped, 2-4 x 1-1.5 µm.
Chemistry: thallus K+ yellow

In rainforest, C. griffithii is known from a single locality (Little Fisher River) where it occurs mostly on dry, fissured bark. Apothecia are rare but the species can be recognised by its distinctive pycnidia. It is also known from subalpine woodland where it occurs on the dry, dead leaves of Richea pandanifolia. Specimens from this habitat are abundantly fertile and with few pycnidia. The species is a new record for Tasmania. A complete description is given by Coppins in Galloway (1985) who considers the species cosmopolitan. However, Tasmanian material differs from his description (loc. cit.) in having a black rather than a pale proper margin to the apothecia.

37(a). Coccotrema cucurbitula (Mont.) Müll. Arg.

Thallus crustose, warty, lumpy or consisting of corticate granules, white-grey to cream. Cephalodia pale pink, convex, irregular, to 1.5 mm across, often rather obscure. Apothecia immersed singly in globular thalline warts to 1 mm wide, with a ± flattened top pierced by a central pore. Spores hyaline, ellipsoid, simple, 46-60 x (18-)22-29 µm.

Chemistry: stictic and constictic acids (main constituents)

A full description is given by Galloway (1985) who cites a Western Pacific distribution, although the species was first described from Chile. The chemical constituents of New Zealand specimens include salazinic, stictic and norstictic acids (Galloway op. cit.). However, salazinic acid was not detected in any Tasmanian specimens whilst those with norstictic acid are treated separately under 37(b). In Tasmania, C. cucurbitula is a common rainforest pioneer species found on canopy twigs, saplings and young branches.

37(b). Coccotrema taxon 1. ("rhodocarpa")

Similar to the above species but with bright red or pink apices to the warts containing apothecia. Spores 51-58 x 24-27 µm.

Chemistry: norstictic acid

This taxon has been recorded from several localities, mainly in south-western Tasmania, where it co-occurs with C. cucurbitula (stictic acid strain). Further collection and study is required to ascertain whether this material could constitute a chemically and macroscopically distinct taxon.

38. Coenogonium implexum Nyl.

Diagnostic features of this species are given on p.36, couplet 23. A full description is given by Galloway (1985). The species is uncommon in rainforest where it is confined to trunks with smooth bark. It is more common in wet sclerophyll forest where it forms extensive mats on the undersides of inclined trunks of several tree species, particularly Pomaderris apetala (Rhamnaceae) and Prostanthera lasianthos (Labiatae).

39. Collema fasciculare (L.) Wiggers

See Galloway (1985) for full description and p.44, couplets 60-63, for diagnostic features. C. fasciculare is one of several pulvinate, gelatinous lichens which occur mainly at the margins of rainforest on shrubs of the Myrtaceae and Compositae. The most common variety, var. fasciculare, is recognised by the absence of isidia, the abundant, clustered large apothecia which ± obscure the thallus, and the vermiform spores, 48-80 x 3-5 µm with 10-16 transverse septa. These features serve to readily distinguish the species from Leptogium brebissonii with which it may co-occur. The earlier record of Collema thysaneum from Tasmania refers to C. fasciculare (Degelius 1974). Two additional varieties of the species, var. microcarpum and var. colensoi, also occur in Tasmania but are not known from within the range of rainforest vegetation. C. fasciculare is cosmopolitan and is common in rainforest in New Zealand (Galloway 1985).

40. Collema glaucophthalmum Nyl.

The species is described in detail by Degelius (1974). Diagnostic features are given on p.45, couplet 68. C. glaucophthalmum is uncommon in rainforest and is best developed at the forest margins on the fibrous bark of species of Compositae, e.g. Cassinia, Olearia and Bedfordia. Two varieties, var. glaucophthalmum (with pruinose fruits) and var. implicatum (epruinose), occur in Tasmania but only the former is known from within the range of rainforest vegetation. The record of C. nigrescens (Huds.)DC. from Tasmania (Wetmore 1963) probably refers to this species. C. glaucophthalmum is also known from Australia, New Zealand, Africa, and South and Central America (Degelius op. cit.).

41. Collema laeve J.D. Hooker & Taylor

See Degelius (1974) for a full description and p.45, couplet 70, for diagnostic features. Additional characteristics are given under C. leucocarpum (below). The proper margin of C. laeve consists of isodiametric cells in var. senecionis or oblong cells in var. laeve. C. laeve is frequent in rainforest where it usually occurs on the twigs of undershrubs and subdominant trees. The species is also known from Australia, New Zealand and southern South America (Degelius 1974).

42. Collema leucocarpum J.D. Hooker & Taylor

See Degelius (1974) for full description and p.45, couplet 70 for diagnostic features. The species can be difficult to distinguish from C. laeve var. laeve. However, the thallus of C. leucocarpum is of ± even thickness and resembles a loosely crumpled membrane, attached where the folds touch the substrate whereas that of C. laeve is like an adnate film, unevenly moulded over the substrate. The diagnostic cellular pseudocortex of the thalline margin of C. leucocarpum is best observed on the lower surface of the apothecium. The proper margin of C. leucocarpum consists of large isodiametric cells. C. leucocarpum is most common at the margins of rainforest on trees and shrubs of the Compositae. It is also known from Australia, New Zealand and South Africa.

43. Collema subconveniens Nyl.

See Degelius (1974) for full description and p.45, couplet 69, for diagnostic features. The species is distinguished from all other Tasmanian representatives of the genus by its muriform spores, 20-38 x 7.5-11 µm. It is common in moist, shaded habitats in rainforest and other vegetation, either directly on bark, on mosses over bark, or on mossy rocks (including limestone). The species is also known from Australia, New Zealand, Japan and the subantarctic islands (Degelius op. cit.).

44. Collema subflaccidum Degelius

The species is described in detail by Degelius (1974) and Galloway (1985). Diagnostic features are summarised on p.44, couplet 67. C. subflaccidum is cosmopolitan (Galloway 1985) but apparently rare in Tasmania and confined mainly to sclerophyllous vegetation at the margins of rainforest.

45. Coniocybe furfuracea (L.) Ach.

Thallus leprose, bright yellow-green. Apothecium a stalked mazaedium, pale brown, to c. 0.4 mm diam. Stalk slender, yellow-green pruinose. Spores pale brown in the mass, simple, spherical, 2.5-3 µm diam.

The species is characteristic of dry, sheltered and shaded rainforest habitats and is commonly found in bark fissures on very old, inclined trees. It is a new record for Tasmania. C. furfuracea

is cosmopolitan and is described in full by Tibell in Galloway (1985).

46. Conotremopsis weberiana Vězda

A description and discussion of this monotypic genus is given by Vězda (1977). Diagnostic features are summarised on p.36, couplet 23. The species usually occurs on Nothofagus cunninghamii in sheltered, moderately dry habitats, often intermediate between the extremely dry trunk faces where Sagenidium, Lecanactis abietina etc. occur, and the opposite, wet mossy inclined faces dominated by Sphaerophorus. Conotremopsis is one of several byssoid-filamentous epiphytes in Tasmanian rainforest and is readily distinguished by its mottley greenish-orange colour and cylindrical apothecia. Extensive, well-developed populations of Conotremopsis occur in rainforests above 700 m altitude around the northern and western rim of the Central Plateau. Elsewhere in Tasmania, the species is usually very rare and infertile. It is also known from New Zealand where it is apparently rare.

47. Degelia durietzii Arvidsson & D. Galloway

A full description is given in Arvidsson and Galloway (1981). Diagnostic features are given on p.51, couplets 108-109. The species is rare in Tasmania where it is confined to canopy twigs in rainforest. Coccocarpia palmicola is somewhat similar but in Tasmania is found only on rocks in sclerophyll vegetation. D. durietzii is also known from New Zealand and Australia.

48. Degelia gayana (Mont.) Arvidsson & D. Galloway

= Coccocarpia gayana (Mont.) Nyl.

See Arvidsson and Galloway (1981) for a full description and p.51, couplets 108-109, for diagnostic features. This species differs from D. durietzii by the absence of isidia and by its abundant apothecia. Moreover, the lobes are frequently marked with concentric ridges and have ± entire margins (the margins are scalloped-notched in D. durietzii). D. gayana is known from New Zealand, southern South America and Tristan da Cunha. In Tasmania, it occurs mainly in wet scrub, heath or at the margins of rainforest where it is commonly associated with Nephroma cellulosum, Sticta limbata and species of Collemataceae and Pannariaceae.

49. Dendriscocaulon dendriothamnodes Dughi in D. Galloway

See Galloway (1985) for a description and p.40, couplet 40, for diagnostic features. The species is abundant amongst mosses in very wet, shaded habitats and occurs either independently or attached to Sticta stipitata. The record of Polychidium umhausense (Auersw.) Henssen by Bratt and Cashin (1975) refers to this species. The lichen is also known from New Zealand and Australia.

50. Dictyonema sericeum (Sw.) Berk.

In growth form, the Tasmanian taxon corresponds to both D. interruptum (Carm. ex Hook.) Parm. as described in Coppins and James (1979) and D. sericeum f. thelophora (Sprengel) Parm. as described by Parmasto (1978). Its photobiont is Scytonema. Basidiocarps are rare and occur as whitish bands, 1-2 mm wide, on the undersides of ascending branchlets of the lichen-encrusted bryophyte substrate. Spores are obovate, 6-7.5 x 2.5-3 µm but are very rare and few mature basidia were seen. However, the complete absence of clamp connections suggest that the Tasmanian taxon is most likely the latter species (see also p.36, couplet 20).

D. sericeum is uncommon in Tasmania. It occurs over bryophytes in deep shade in rainforest and wet scrub. The species is also known from tropical Australia, America and Asia as well as from New Zealand.

51. Dimerella lutea (Dicks.) Trevisan

Thallus crustose, thin, greyish green. Apothecia lecideine, bright orange, concave or plane, to 3 mm diam. Paraphyses simple, with knob-like tips. Spores hyaline, 8/ascus, narrow ellipsoid, 1-septate, 7-14 x 3-4 µm.

D. lutea is mostly epiphytic, usually over mosses in deep shade, and is best developed on the trunks of Dicksonia antarctica. The species is cosmopolitan and is described fully by Galloway (1985).

52. Fuscidea sp.

Thallus crustose, dark olive-brown. Apothecia lecideine, black, to c. 0.8 mm diam., plane, roundish, with a distinct, ± inrolled, flexuose margin. Epithecium dark red-brown, c. 12 µm thick. Hymenium colourless, c. 35 µm thick. Hypothecium colourless, c. 60 µm thick.

Paraphyses simple or branched once, with red brown, swollen tips, separating in K. Spores simple, hyaline, 8/ascus, oblong-ellipsoid, with blunt ends, curved, 9-10 x 2.5 µm.
Chemistry: fumarprotocetraric acid

Fuscidea sp. is a small pioneer species of canopy twigs. It is common at Little Fisher River but has probably been overlooked elsewhere.

53. Graphis scripta (L.) Ach.

Thallus crustose, whitish grey, thin or thick and cracked. Lirellae curved, serpentine, branched, dispersed. Thalline margin usually evident. Proper margin raised, black, closing with a slit and obscuring the disc. Spores hyaline, 16-26 x 6-9 µm, with 5-9 (usually 7) lenticellular locules.

The species is common in rainforest on the lower parts of trunks with smooth bark. The exact identity of the Tasmanian material remains unclear and further collection and study of the genus as a whole is required. Some specimens contain norstictic acid and have been confirmed as G. scripta by Mr. P.W. James. Others, however, lack norstictic acid and contain only unidentified substances. The Tasmanian taxon may be conspecific with the New Zealand species, G. librata Knight, which also contains norstictic acid (see Galloway 1985).

54. Graphis insidiosa (Knight & Mitten) J.D. Hooker

Thallus yellowish to greenish grey, cracked, wrinkled and bordered by a black prothallus c. 1 mm wide. Lirellae curved or contorted, little branched, thalline margin thick, prominent, raised, proper margin pale brown. Spores hyaline, 4-locular, 18-26 x 8-10 µm, end to end in the ascus.
Chemistry: no substances detected

G. insidiosa is a new record for Tasmania where it is uncommon on rough or smooth bark in rainforest. The species is also known from New Zealand [see Hayward (1977) for a full description].

55. Gymnoderma melacarpum (F. Wilson) Yoshimura

= Neophyllis melacarpa F. Wilson

= Phyllopsora melanocarpa Müll. Arg.

A full description and discussion of this species is given by Yoshimura (1973) and Galloway (1985). The species is recognised by its crowded, coralloid-terete to ± flattened, incised squamules which support black, subglobose apothecia on indistinct, short podetia (see also pp. 37 and 42, couplets 27 and 51).

G. melacarpum is common in wet forests on the fibrous bark of Eucalyptus buttresses where it is associated with Lepraria incana and Cladonia squamosula. It is also found on peat mounds derived from Eucalypt litter. Outside forest, the species can occur on soil, particularly in high altitude sedgeland-heath. In extreme shade, the squamules become decumbent, very delicate and elongated (up to 10 mm in contrast to the average 1-2 mm). Gymnoderma melacarpum is also known from Australia and New Zealand.

56. Haematomma infuscum (Stirton ex Bailey) R.W. Rogers

Thallus whitish grey, thin, often ± patchy. Apothecia lecanorine, to 1 mm diam. Disc plane, rarely convex, orange-red. Thalline margin thin, somewhat inrolled, crenulate. Epithecium c. 12 µm thick, orange-red, K+ magenta (± fading). Hymenium colourless, 50 µm thick. Hypothecium colourless to pale orange, K+ magenta, 50 µm thick. Spores hyaline, asymetrically narrow-fusiform, with rounded or pointed ends, 6-10 locular, 38-48 x 2.5-5(-7) µm.
Chemistry: atranorin

H. infuscum is a widely distributed but uncommon species of canopy twigs in rainforest, occasionally also found on trunks with smooth bark in open habitats. The species is described by Rogers (1982) and is also known from Australia. One specimen from subalpine scrub at Lake Skinner, Mt. Snowy South, has larger spores [(50-)72-84 x (4-)6-12 µm with 16-18 locules] but has also been determined as H. infuscum by Dr. R. W. Rogers.

57. Heterodermia microphylla (Kurok.) Swinsc. & Krog

Thallus foliose, lobes elongate, much branched, crowded, with marginal squamules which may become finely dissected, abraded or coarsely sorediate. Margins of lobes with black cilia and rhizines, the latter turned downwards, often very densely branched and forming

a tangled mat, anchoring the thallus. Underside ecorticate, white, sometimes discoloured greyish in the oldest (central) parts of the thallus. Apothecia not seen in Tasmanian material.
Chemistry: atranorin and terpenes

See Galloway (1985) for a full description and p.52, couplet 116, for a summary of diagnostic features. The species is locally abundant in some rainforests in north-western Tasmania on smooth or moderately rough trunks in well-lit habitats. It is also known from Australia, New Zealand, East Africa and Japan.

The genus is very poorly known in Tasmania where it is most common in dry sclerophyll forest and coastal vegetation. A second species (with an ecorticate underside, delimited marginal labriform soralia and containing norstictic acid) is known from a single, small, rainforest collection. On the basis of the papers of Swinscow and Krog (1976) and Galloway (1985), this specimen corresponds to H. japonica (Sato) Swinsc. & Krog.

58. Hypogymnia lugubris (Pers.) Krog

See Elix (1979) for a full description and p.46, couplet 77, for diagnostic features. The species is recognised by its hollow, narrow, elongate and separate lobes and the Pd+ orange-red reaction of the medulla. It is an uncommon rainforest canopy species but is very abundant in alpine and subalpine vegetation. H. lugubris is also known from Australia, New Zealand, New Guinea and southern South America.

Rainforest specimens of H. lugubris are often small and poorly developed and may be confused with H. turgidula (see below). Another potentially confusing species is H. enteromorphoides which is similarly Pd+ orange-red and occurs in open eucalypt forest. This species is distinguished by its contiguous central lobes and clustered apothecia. However, younger thalli on twigs have poorly developed central contiguous lobes, more elongate marginal lobes and hence intergrade with H. lugubris. Such forms of H. enteromorphoides have been recorded (rarely) from marginal rainforest situations.

59. Hypogymnia mundata (Nyl.) Rassad.

See Elix (1979) for a full description. The species is recognised by its solid, usually ± flattened lobes (see also p.46 couplet 76). It is an occasional rainforest canopy species, widespread throughout Tasmania from sea-level to alpine habitats, and is also known from Australia and New Zealand.

60. Hypogymnia subphysodes (Kremp.) Filson

See Elix (1979) for a full description and p.46, couplet 75, for diagnostic features. The species is recognised by its hollow lobes with laminal soralia. It is uncommon in rainforest where it occurs on well-lit trunks, mostly in high altitude callidendrous rainforest in north-eastern Tasmania. Rainforest specimens have narrow, elongate lobes and are H. subphysodes var. subphysodes. A second variety, H. subphysodes var. austerodioides Elix, is widespread outside rainforest on bark, wood or rocks. H. subphysodes is referred to in early literature as Parmelia physodes. It is also known from Australia, New Zealand and southern South America.

61. Hypogymnia turgidula (Bitter) Elix

See Elix (1979) for a full description and p. 46, couplet 77 for diagnostic features. The species is similar to H. lugubris but has lobes which are contiguous in the centre of the thallus and become elongate and upturned towards the margin. However, both species may intergrade and the Pd- reaction of the medulla is the most reliable distinguishing feature. H. turgidula is the most common rainforest species of the genus, occurring in the forest canopy with species of Usnea and Menegazzia. It is widespread in Tasmania and is also known from New Zealand and Australia.

62. Lecanactis abietina (Ach.) Körb.

Thallus crustose, thin, ± diffuse, pale grey with a faint pinkish tinge. Apothecia lecideine, to 1.5 mm diam. Disc plane, dark brown to black, very densely yellowish-grey pruinose. Margin black, sparingly pruinose. Epithecium black, turning colourless in K. Spores hyaline, 8/ascus, 3-septate, fusiform, slightly curved, (23-)26-36 x 3.5-6 µm. Pycnidia conspicuous, cylindrical, with white powdery tips. Conidia ellipsoid, 11-15 x 4.5 µm.

Chemistry: lecanoric acid (C+ red) in tips of pycnidia only, schizopeltic acid

The species is widespread in Tasmanian rainforest where it is confined to the very dry, fissured bark of mature, inclined trunks of Nothofagus cunninghamii. It is usually associated with Sagenidium molle, Chaenotheca brunneola and Lepraria incana. Specimens are usually abundantly fertile and the formation of pycnidia is either totally suppressed or confined to the periphery of the thallus. However, occasional large individuals are sterile and completely covered with pycnidia. Previously known only from the temperate Northern Hemisphere, this species is a new record for Tasmania and the Southern Hemisphere.

63. Lecanactis subpremnea A. Vězda, sp. nov. ad interim

Ex affinitate Lecanactis premneae, a qua differt paraphysibus in apice haud nigrifuscis, sporisque valde majoribus, 30-45 µm longis.

Thallus crustose, very thin, dark olive-green. Apothecia lecideine, black, plane, to 1.7 mm diam., with a prominent proper margin, ± inrolled and lightly pruinose on the inner edge in very young apothecia. Exciple and hypothecium brownish black, ± greenish black in K. Epithecium dark brown, becoming colourless in K. Hymenium colourless. Spores hyaline, 8/ascus, narrow fusiform, 30-45(-50) x 4.5-7.5 µm, 7-8 septate.

This species is similar to the Northern Hemisphere species, L. premnea (Ach.) Arnold, from which it differs in the ± uncoloured paraphyses (in L. premnea, these remain apically black in K) and the larger spores (18-25 x 5-7 µm in L. premnea). It is very rare and known from a single locality in western Tasmania. The species occurred on the buttress of mature, very rough-barked Nothofagus in thamnic rainforest.

64. Lecanactis sp.

Thallus crustose, very pale greyish fawn, thin. Apothecia lecideine, to 0.8 mm diam. Disc black, densely pale grey pruinose when young, plane to concave, occasionally becoming convex. Margin thin, milky white. Epithecium brown, becoming colourless in K. Hymenium colourless. Hypothecium dark brown, black in the lower part,

± yellowish brown in K. Spores hyaline, 8/ascus, narrow fusiform, 33-56 x 3.5-5 µm, (3-)7 septate.
Chemistry: thallus K+ yellowish, C-, Pd-, UV-

The species is apparently rare and known from a single collection from relict rainforest on the Eastern Tiers, eastern Tasmania. It occurred in shade on Atherosperma moschatum, associated with Thelotrema lepadinum, Pyrenula sp. and other crustose lichens.

65. Lecanora atra (Huds.) Ach.

Thallus crustose, greyish white, smooth to warted-aereolate. Apothecia lecanorine, to 1.5 mm diam. Disc black, concave, plane or ± convex. Epithecium dark purplish-brown, intensifying purplish in K. Spores hyaline, simple, ovate to ellipsoid, 10-15 x 6-10 µm.
Chemistry: atranorin (cortex K+ yellow), α-collatolic acid, ± alectoronic acid (medulla UV+ ice-white, best observed in the medulla beneath the apothecia)

The species is rare in rainforest where it occurs on canopy twigs or smooth trunks in clearings. However, it is extremely common in low rainfall areas in Tasmania and is found both on rocks and as an epiphyte in coastal habitats, sclerophyll forest and in parks and pastures. Further data are provided by Galloway (1985). The species is cosmopolitan.

66. ?Lecanora sp.

Thallus crustose, pale yellow, rather thick, warty-aereolate. Apothecia to 2 mm diam., with disc black or dark grey, ± pruinose, plane to convex, often deeply lobed. Thalline margin prominent, flexuose, ± inrolled.
Chemistry: thallus C+ red (persistent)

This species is known from a single fragmented gathering amongst Lecanactis abietina. It occurred on a very old, dry, fissured buttress of Nothofagus cunninghamii at the edge of rainforest in the Styx Valley, south-western Tasmania. The hymenium of the apothecia is badly eroded and hence no spores could be found, making the specimen unidentifiable. It is included here because its habitat suggests it is an "old forest" species. Furthermore, with the exception of the previous species, Lecanora does not occur in rainforest and hence

this collection is of some interest. The species could be related to L. varia or L. symmicta from Europe (P. James pers. comm.).

67. Lecidea ceroplasta (Church. Bab.) J.D. Hooker

Thallus crustose, pale grey, white or cream, thin to rather thick. Apothecia orange-brown, rarely yellow-orange or red, to 2 mm diam., flat with a thin margin, soon becoming immarginate, convex or almost globular. Exciple and epithecium pale to dark orange, sometimes brown with the inner edge yellow, K+ crimson (or yellow, see below). Hypothecium colourless or pale orange-brown, to 400 µm thick and sometimes clearly bulging out from beneath the hymenium. Hymenium and hypothecium densely interspersed with oil droplets, dissolving in K. Spores hyaline, ellipsoid, 17-25 x 7-12 µm.

The species is common and widespread in rainforest and occurs mainly on Nothofagus, Phyllocladus and Anodopetalum. It is usually found on the smooth, younger, middle regions of the trunk or on low branches, but not in the canopy. L. laeta is similar but has more scarlet, plane, irregularly discoid apothecia, smaller spores and, in rainforest, is a canopy twig species. The variable K reaction of the exciple and epithecium appears to be linked with the age of the apothecia. Tiny, dot-like, red apothecial initials are K+ crimson. With age, these develop the typical orange-brown colour, still K+ crimson. However, the oldest, ± globular apothecia are K+ yellow. L. ceroplasta is a new record for Tasmania. It also occurs in New Zealand (see Galloway 1985). The species has been recently transferred to Miltidea by Galloway and Hafellner in Hafellner (1984).

68. Lecidea (Trapeliopsis) cf. granulosa (Hoffm.) Ach.

Thallus crustose, consisting of minute contiguous granules, dark to pale green. Apothecia lecideine, to 0.8 mm diam., usually crowded. Disc slightly concave, plane or (rarely) convex, pale orange-brown, flesh-coloured or brown, with a thin, pale proper margin. Internal parts of apothecium pale straw to colourless, hymenium c. 50-70 µm thick. Spores simple, hyaline, rather variable in shape, broadly ellipsoid, ovate to almost spherical, (5-)8-11 x 4-5 µm.

Chemistry: thallus C+ red (gyrophoric acid)

L. granulosa is widespread in the high rainfall areas of Tasmania on humic soil or rotting wood, particularly at subalpine to alpine altitudes. It is uncommon in rainforest and is mainly confined to high altitude callidendrous communities where it occurs on tree buttresses, rotting logs and peat. It is often associated with Phyllopsora congregans which is somewhat similar but differs in its more lobate, squamulose thallus and its larger, brick-red apothecia.

69. Lecidea laeta Stirton

Thallus crustose, sordid greyish, usually very thin. Apothecia lecideine, bright red, to 0.8 mm diam., plane to slightly convex, often crowded and confluent. Exciple and epithecium golden-brown, K+ crimson. Spores simple, hyaline, ellipsoid, 9.5-12 x 3.5-5 µm.

L. laeta is uncommon in rainforest and confined to the uppermost canopy twigs of the tallest trees. However, it is very common on exposed trunks and twigs in pasture, heath and sclerophyll forest. The original description (Stirton 1898), based on a Tasmanian specimen, cites larger spores (13-19 x 3-3.5 µm). The species is also known from Australia and New Zealand and a complete description is given by Galloway (1985). It has also been recorded from Tasmania under the name L. cinnabarina Sommerf., a Northern Hemisphere taxon.

70. Lecidea sp.1

Thallus crustose, very thin, effuse, pale grey. Apothecia to 0.8 mm diam., irregularly roundish, often crowded and confluent. Disc plane to convex, uneven, glossy, ± translucent pale flesh brown to reddish brown, with a thin concolorous margin when young, becoming immarginate in older fruits. Epithecium colourless to pale red-brown. Hymenium colourless to very pale brown, c. 40 µm thick. Hypothecium colourless, dense, c. 200 µm thick. Spores simple hyaline, ellipsoid-fusiform, 9.5-12 x 2.5-4 µm.
Chemistry: thallus Pd-, K-, C-, KC-

Lecidea sp.1 is a pioneer species of young, smooth Nothofagus in rainforest at the Little Fisher River but has probably been overlooked elsewhere.

71. Lecidea sp.2

Thallus crustose, thin, effuse, pale greenish-grey. Apothecia lecideine, to 1 mm diam. Disc pale to reddish brown, matt, plane when young, becoming convex. Margin thin, concolorous with disc, persistent except in the oldest, most convex fruits. Hymenium colourless, c. 70 µm thick. Hypothecium colourless, very dense, c. 400 um thick. Spores simple, hyaline, ellipsoid, 12-18 x 7-12 µm.
Chemistry: thallus Pd-, K-, C-, KC-

Lecidea sp.2 is known from several widespread localities in rainforest, mainly from shaded trunks of Atherosperma. It is rather similar to the preceding taxon and is best recognised by its larger spores, mostly dispersed apothecia and smooth, matt apothecial disc.

72. Lecidea sp.3

Thallus crustose, rather thick, aereolate, glaucous grey, bordered by a black prothallus 1-2 mm wide. Apothecia lecideine, black, roundish or irregularly shaped, to c. 2 mm across, often crowded and confluent, adnate, very flattened. Disc plane or concave, rugose, uneven. Margin very thin. Epithecium pale orange-brown. Hymenium pale brown to colourless, lighter above, darker below, 40-50 µm thick. Hypothecium dark reddish brown, c. 70 µm thick (all parts ± unchanged in K). Spores hyaline, simple, ellipsoid, 7-10 x 4.5-5.5 µm.
Chemistry: thallus K-, KC-, Pd-, C-

The species is uncommon and occurs on twigs and young branches in moderate shade.

73. Lecidea sp.4

Thallus granular-leprose to scurfy, crustose, dull mustard yellow, spreading unevenly. Apothecia to 0.3 mm diam., grey to black, strongly convex, immarginate, often rather deformed and with "secondary", superficial, developing apothecia. Hymenium c. 25 µm thick, ± yellowish brown in the lower part, colourless above, K- (or ± faintly violaceous). Hypothecium dark brown, opaque, K- or with a ± dull yellow-green tinge. Paraphyses simple or forked, c. 1-1.5 µm wide, not swollen above, bound by a gel matrix (even in K). Spores simple, hyaline, oblong-ellipsoid, (6-)7-9.5(-11) x 2-2.7 µm.
Chemistry: thallus K-, KC-, C-, Pd-, UV-

Lecidea sp.4 is rare and known from a single collection from Little Fisher River. It occurs on very dry trunks of Nothofagus cunninghamii in deep shade and is associated with Lecanactis abietina, Sagenidium and species of Arthonia, Catillaria and the Caliciales. The species has been provisionally identified by Dr. B. Coppins who also provided some of the descriptive data above.

74. Lecidella elaeochroma (Ach.) Choisy aggr.

Thallus crustose, often rather thick and wrinkled, creamy grey to dull olive-yellow (see "chemistry" below), sometimes with a black prothallus, visible at the margins or between cracks in the thallus. Apothecia lecideine, to 1.5 mm diam., dispersed or clustered in groups of 2 or 3 (then often confluent). Disc plane to convex, often undulate, black to occasionally pale grey with a faint bluish tinge. Margin black, shiny, prominent, ± crenulate to flexuose. Epithecium and outer edge of exciple aeruginose blue-black (rarely black-brown), ± greenish in K. Hymenium c. 50 µm thick, colourless, K-. Hypothecium c. 150 µm thick, colourless, K-. Inner edge of exciple colourless, K-. Paraphyses simple, lax and separating easily in K. Spores simple, hyaline, 14-20(-25) x 5-8(-10) µm, with a distinct wall.
Chemistry: thallus K+ yellow (often faint), C+ orange in olive-yellow thalli, C- in grey thalli

The species is very common on twigs and trunks in high rainfall areas of Tasmania from sea-level to alpine altitudes. It is one of the most common epiphytes on trees and shrubs (particularly Banksia) in sedgeland-heaths and low open woodlands. However, it is uncommon in rainforest and is usually confined to the canopy.

In Tasmania, L. elaeochroma is variable with respect to the colour of the thallus and the apothecial disc. Generally, specimens from shaded habitats (e.g. rainforest) have a pale thallus (C-) and a pale greyish disc. In contrast, individuals from exposed habitats are yellowish olive (C+ orange) and the apothecia are black throughout. A range of Tasmanian material has been compared with L. elaeochroma s.str. by Mr. P. James who observes that the Tasmanian taxon differs chiefly in its longer, more pointed spores and the colourless (instead of red-brown) hypothecium. The Tasmanian material likewise differs from the New Zealand entity as described by Galloway (1985). L. elaeochroma aggr. has not been recorded previously from Tasmania.

75. Leioderma amphibolum (Knight) P.M. Jørg. & D. Galloway ined.

= Parmeliella amphibola (Knight) Müll. Arg.

See Galloway (1985) for a full description. Diagnostic features are given on p.51, couplet 111. All Tasmanian specimens seen are sorediate, non-fertile and rarely more than 3 cm across. The lobes are markedly incised and often appear ± dispersed, particularly where the lichen is associated with and partially overgrown by bryophytes. The species is widespread in Tasmanian rainforest, either amongst bryophytes (usually Radula spp.) or directly on smooth bark. It is found in moderately open habitats, e.g. the middle to upper parts of forest trees, and is most common at subalpine altitudes where it is associated with Parmelia testacea, Pertusaria nothofagi and Menegazzia weindorferi.

76. Leioderma pycnophorum Nyl.

= Parmeliella pycnophora (Nyl.) Santesson

A full description is given in Galloway (1985). Diagnostic features are given on p.51, couplet 110. L. pycnophorum is abundant on twigs and branches at the scrubby margins of rainforest, in wet scrub or in the understorey of some open wet eucalypt forets. It is found mostly on trees and shrubs of the Compositae, Myrtaceae and on Coprosma nitida and Acacia mucronata. Associated lichens usually include Nephroma cellulosum, Sticta limbata, S. sublimbata and species of the Pannariaceae and Collemataceae. The species is very rare in closed rainforest where it is confined to canopy twigs.

77. Leioderma sorediatum P.M. Jørg. & D. Galloway ined.

Diagnostic features are given on p.51, couplet 111. The species is very rare and known in Tasmania from a single, small, infertile, fragmented gathering from the Arthur River area. The specimen occurred over mosses on dead Nothofagus cunninghamii at the edge of thamnic rainforest.

78. Lepraria incana (L.) Ach. aggr.

Thallus leprose, mostly glaucous grey to greenish grey, forming a thick soft crust in small irregular spots or in large continuous expanses to 30 cm or more across.

Chemistry: Several chemical strains have been recorded in Tasmania. The most common contains atranorin, zeorin, stictic acid, constictic acid and peristictic acid and is also recorded from New Zealand by Galloway (1985). A second common strain contains barbatic and 4-O-demethylbarbatic acids. No morphological or ecological differences are evident between these strains and both may be present within the one population. Two further chemical strains are known from single collections only. One is Pd+ red and contains ?protocetraric acid. The other contains atranorin only and has a pure white-grey thallus.

The species is common and widespread in dry, sheltered habitats throughout most of Tasmania (except in alpine areas) on rocks, soil, wood, bark or bryophytes. In rainforest, the species is extensive on dry, underhanging trunk faces where it is associated with Lecanactis, Sagenidium etc. However, it is also very opportunistic and occurs as small thalli in marginally drier micro-habitats within most rainforest lichen communities. Lepraria incana is cosmopolitan but has not been recorded previously from Tasmania. The record of Crocynia mollescens Nyl. in Wetmore (1963) probably refers to a Lepraria sp.

79. Lepraria membranacea auct.

L. membranacea is similar to the preceding species but has a very pale yellow tinge and usually thicker, more delimited margins. It is distinguished with certainty only by its chemistry which includes pannaric acid (this can be detected by the C+ greenish-grey reaction of the acetone extract, spotted on a t.l.c. plate). The species is uncommon and known only from rainforest in habitats similar to those of L. incana. It is a new record for Tasmania.

80. Leptogium azureum (Sw.) Mont.

= L. tremelloides (L. F.) S.F. Gray

See p.44, couplets 65-66, and Jorgensen and James (1983, p.112) for diagnostic features, and Galloway (1985) for a complete description. Tasmanian material differs only in its slightly larger spores, 25-33 x 9-13 µm with 4-7 transverse and 1-3 longtitudinal

septa. The species is locally common in wet sclerophyll forests and at the margins of rainforest, mostly on shrubs of the Compositae and on the buttresses of some Eucalyptus species (subgenus Symphyomyrtus). Leptogium azureum is usually associated with Nephroma cellulosum and species of Collema and Pannariaceae. Galloway (1985) regards the species as pantropical.

81. Leptogium brebissonii Mont. in Webb & Berthelot

See Galloway (1985) for a full description and pp.43-44, couplets 60-63, for diagnostic features. No fertile Tasmanian material has been seen and all specimens are very small (< 2 cm across) and with irregular, wart-like isidia. The species is widespread but rarely abundant in wet scrub or at the margins of rainforest on twigs and small branches of shrubs of the Myrtaceae and Compositae. It is usually associated with species of Collema.

Leptogium brebissonii is one of a number of pulvinate, gelatinous species which occur in this habitat. In general, the absence of apothecia and the abundant wart-like isidia are sufficient for its recognition. Its cellular cortex is diagnostic although sectioning of the pulvinate species can be awkward. Should the species be found fertile, its spores would be submuriform, fusiform and therefore quite distinct from any possibly confusing Physma or Collema species. Collema fasciculare var. microcarpum, not included in this account, is perhaps the most similar species in that it has granular isidia and indistinct, tiny, immersed apothecia.

82. Leptogium limbatum F. Wilson

Thallus very thin, papery, lead-grey, to 10 cm across, not swelling when wet, margins of lobes entire and ± rounded, crenulate or ± deeply incised and lobulate, often ascending or recurved when dry. Upper surface smooth, undulate, matt, isidiate. Isidia squamiform, sometimes minute and ± granular, laminal, marginal or submarginal, usually in distinct regions. Lower surface with a dense, white, short tomentum, usually with a naked marginal zone, 1-2 mm wide. Apothecia not seen.

L. limbatum is occasional over bryophytes on soil, rocks, logs and tree buttresses in high altitude rainforest. Species of Leptogium sect. Mallotium occur in many wet habitats throughout Tasmania, particularly in some lowland wet sclerophyll communities which

contain Cassinia aculeata and Helichrysum dendroideum. However, the above account is restricted to the rainforest taxon only (see also p.44, couplet 65). L. limbatum is recorded from New Zealand by Galloway (1985) but his description is of a fertile, non-isidiate species. Wilson's original description (based on a specimen from Victoria) is of a plant with dense squamiform isidia ["...pro magna parte limbo squamoso ornatus..." (Wilson 1891)].

83. Leptogium victorianum F. Wilson

Thallus dark bluish grey, often with a brownish tinge, thin to robust, undulate and folded, wrinkled on the upper and lower surfaces, with irregularly incised or broadly rounded, ± ear-shaped, ascending lobes. Isidia squamiform, sparse to very dense, marginal and laminal, occasionally in rows along the wrinkles, sometimes becoming large and lobe-like. Apothecia to 3 mm diam., with margin wrinkled, scabrid or, rarely, isidiate. Disc reddish-brown to dark brown, concave to plane, becoming convex with age. Spores hyaline, 8/ascus, ellipsoid, (13-)17-24 x (5-)7-8.5 µm, with 3 transverse and 1 longtitudinal septa.

The species is very widespread and common on soil, rocks, logs or bark, and ranges from dry sclerophyll vegetation to wet forests. In drier habitats, it is usually finely dissected, with crowded, erect or ascending ear-shaped lobes and dense isidia. The brown thallus colour seems to be a response to increasing exposure. In rainforest, the species is blue-grey, flat or undulate, and broadly lobed. The wrinkles may be faint or very pronounced and flanged. The species is also known from Australia.

84. Lopadium disciforme (Flotow) Poelt & Vězda

Thallus crustose, very thin, aereolate, dark brownish-grey. Apothecia lecideine, dull black, to 1 mm diam., minutely scabrid. Hypothecium, epithecium and exciple brown to black. Apices of paraphyses black, capitate. Spores hyaline to pale greyish, 1/ascus, muriform, thin-walled, (65-)79-110 x (22-)27-38 µm.

L. disciforme is very rare in Tasmania and known only from forests in north-western Tasmania where it occurs on Nothofagus cunninghamii. Closely related to L. pezizoideum, the species was

previously known only from the temperate Northern Hemisphere and is a new record for Tasmania.

85. ?Lopadium sp.

Thallus crustose, greyish, very thin, scurfy, evanescent. Apothecia lecideine, to 1 mm diam., with plane, fawn disc and thin, dark brown margin. Epithecium and hymenium colourless or pale greyish brown, becoming colourless in K. Hypothecium and exciple reddish brown, becoming grey-brown in K. Paraphyses slender, < 1 µm thick, sparingly branched, without markedly capitate apices. Spores hyaline, 8/ascus, sparingly muriform or submuriform, mostly with 8-9 transverse and 1-3 longtitudinal septa, ellipsoid, 21-42 x 7-10 µm, with markedly pointed, apiculate ends.

The species is extremely rare and known from a single small collection from a rough, dry trunk of Nothofagus cunninghamii in rainforest at Little Fisher River. Associated lichens include Lecanactis abietina and other characteristic "dry trunk" species.

86. Megalaria grossa (Pers. ex Nyl.) Hafellner
= Catillaria grossa (Pers. ex Nyl.) Körber

Thallus crustose, pale greenish grey. Apothecia lecideine, to 2.5 mm diam., black, plane to convex, with a distinct margin sometimes ± obscure at maturity. Epithecium blue-black. Hymenium pale brown or colourless, K± purplish (very weak). Hypothecium blue-black, opaque. Spores hyaline, 1-septate, (17-)24-31 x (9-)12-17 µm.

M. grossa is uncommon in rainforest and is known from a single collection from the fibrous bark of Bedfordia salicina (Compositae) in "mixed forest" in northern Tasmania. However, several similar collections from analogous habitats remain undetermined and the species may well prove to be more widespread. M. grossa is cosmopolitan and additional data are given in Poelt and Vězda (1981) and Galloway (1985) (under Catinaria).

87. Megaloblastenia marginiflexa (J.D. Hook. & Taylor) Sipman
= Megalospora marginiflexa (J.D. Hook. & Taylor) Zahlbr.
= Blastenia endochromoides (Nyl.) Müll. Arg.

Thallus crustose, whitish grey with a very faint bluish tinge. Apothecia lecideine, to 3 mm diam. Disc plane to undulate, dark brown, with sparse grey pruina, giving a ± purplish tint. Margin ± flexuose, slightly inrolled, outer surface yellowish. Spores hyaline, polarilocular, 24-40 x 14-24 µm.
Chemistry: pannarin, zeorin

See Sipman (1983) for a full description. The species is common and widespread, mostly in callidendrous rainforest and some wet sclerophyll communities. It occurs in open habitats, mainly on smooth barked trunks and branches in clearings or in the canopy. Tasmanian material always lacks soredia. The species is also known from Australia, New Zealand and South America.

88. Megalospora campylospora (Stirton) Sipman

Thallus crustose, greyish white, thick, wrinkled and cracked, granular sorediate. Apothecia lecideine, to 3 mm diam. Disc plane, undulate to slightly convex, pale greyish pruinose. Margin thick, black, prominent. Exciple K+ red in section. Spores 1-6/ascus, 1-septate, mostly straight, (45-)60-80 x (19-)34-40 µm, with wall c. 2.5 µm thick.
Chemistry: pannarin, zeorin

See Sipman (1983) for a full description. The species is rare in Tasmania and known from only two collections (one, during the present study, from relict rainforest at Douglas River, eastern Tasmania). However, it is possible that it is more common as sterile thalli that have been overlooked. Sipman (1983) reports that only Tasmanian specimens are sorediate. M. campylospora is also known from Lord Howe Island and from New Zealand where it is common.

89. Megalospora lopadiodes Sipman

Thallus crustose, whitish grey, thick and often cracked. Apothecia lecideine, to 2.5 mm diam., glossy. Disc plane, reddish brown to black. Margin black, prominent, thick. Spores hyaline, 1/ascus, irregularly muriform with ∞ cells and thin septa, 60-90 x 25-35 µm.

Chemistry: pannarin, zeorin

See Sipman (1983) for a full description. M. lopadioides is the most common Tasmanian species of the Megalosporaceae. It is widespread and common in high rainfall areas in rainforest (mostly thamnic communities) as well as in marginal wet scrub and heath. It also occurs in sheltered microhabitats on rocks in sedgeland-heath in south-western Tasmania. Although best developed in well-lit habitats, it is not a canopy species but occurs instead on thick, moderately smooth bark in clearings and along tracks and streams. The winter deciduous tree, Nothofagus gunnii, can be a particularly favoured phorophyte.

The species is also known from a single collection from south-western Western Australia. This seems a curious disjunction and it is possible that there has been a muddling of lables in the time following the death of the collector (G.C. Bratt) before his herbarium was curated. Similar examples of such mis-labelling have been found in his collection.

90. Megalospora subtuberculosa (Knight) Sipman

Thallus crustose, thin, yellowish, with ± round, raised soralia c. 1-2 mm wide. Apothecia lecideine, brown-black, to 1.5 mm diam., with plane disc and very thick, prominent margin. Spores 6-8/ascus, 1-septate, 26-38 x 14-27 µm, with wall 2-2.5 µm thick.
Chemistry: usnic acid, zeorin

See Sipman (1983) for a full description. As with M. campylospora (above), the spores in Tasmanian material are not curved. The species is extremely rare and known from two fragmented collections from north-western Tasmania. Only one of these is fertile, (very sparingly) but the species is nevertheless identifiable by its chemistry. M. subtuberculosa was previously considered endemic to the North Island of New Zealand and is a new record for Tasmania.

91. Menegazzia bullata (Stirton) Bitter

General features of the genus Menegazzia are given in Galloway (1985) and in the key (p.45, couplets 71-73). Diagnostic features of M. bullata are given on p.47, couplet 87. The species has 2 spores/ascus, 43-52 x 24-27 µm, but mature spores are rather rare.
Chemistry: atranorin, menegazziaic acid, stictic acid complex (medulla K+ yellow, Pd+ orange)

The species is common in subalpine and alpine heath and scrub on twigs and young branches. It is rare in rainforest and is usually confined to high altitude communities with broken canopies. The species was first described from New Zealand by Stirton (1900) but is not included in Galloway (1985).

92. Menegazzia caliginosa P. James & D. Galloway

Diagnostic features of the species are given on p.47, couplet 82. A full description is given by Galloway (1985). M. caliginosa is a sorediate species with a pale grey-green (rather than whitish grey) upper surface and is recognised with certainty only by its pigmented internal wall. No fertile material is known from Tasmania. The species is rare in Tasmania and occurs on smooth bark in well-lit rainforest habitats. It is also known from New Zealand.

93. Menegazzia eperforata P. James & D. Galloway

See Galloway (1985) for a full description and p.46, couplet 74 for diagnostic features. M. eperforata is one of only three species in the genus which lack perforations and are isidiate. The others are M. minuta (see below) and an undescribed taxon from New Guinea (see Galloway op. cit.). M. eperforata is locally common at a small number of localities in north-western and north-eastern Tasmania. It occurs mostly on exposed, fissured trunks of Nothofagus cunninghamii and is often associated with M. nothofagi. The species is also known from New Zealand, Australia and Lord Howe Island.

94. Menegazzia globulifera R. Sant.

See Galloway (1985) for a full description and p.46, couplet 79, for diagnostic features. It is the only yellow species in the genus and is confined to high altitude vegetation where it is associated with Hypogymnia lugubris, Pertusaria nothofagi and other Menegazzia spp. It is rare in rainforest and occurs mostly on exposed

trunks and twigs in clearings. M. globulifera also occurs in New Zealand and southern South America. The record of the species from Australia by Filson and Rogers (1979) refers to M. caesiopruinosa P. James ined., a lowland, dry sclerophyll forest species.

95. Menegazzia inactiva P. James ined.

Thallus ± rosette-shaped, to 5 um across, upper surface whitish grey, smooth, sorediate. Lobes 1.5-3 mm wide, swollen, subterete, overlapping in the centre of the thallus, margins often with numerous, smaller adventitious lobes which may become upturned, torn and sorediate. Perforations scattered, 0.5-1 mm diam., becoming elevated and forming open cones to 2.5 mm high, edges torn outwards and irregularly sorediate. Apothecia unknown.
Chemistry: atranorin, fatty acids (medulla K-, KC-, C-, Pd-)

M. inactiva has been found on the twigs and smooth-barked branches of Tasmannia, Phyllocladus and Phebalium squameum (Rutaceae) in mature "mixed forests" with broken canopies. Associated lichens include Pertusaria nothofagi, Coccotrema cucurbitula, Austroblastenia pauciseptata and Menegazzia spp. It is a very rare endemic species known from only two localities (near Arthur River, north-western Tasmania, and Boyd River, south-western Tasmania). The former site, where the species was locally common, has since been clear-felled.

96. Menegazzia minuta P. James ined.

Thallus ± irregularly rosette-shaped, mostly < 10 mm across, closely adnate, isidiate. Lobes < 1 mm wide, ± flattened, discrete and well-separated at the thallus margins, ± crowded in the centre. Upper surface olive-brown to suffused reddish brown, glossy. Perforations absent. Isidia ± globular, rather sparse, hollow, mainly along the lobe margins. Apothecia not seen.
Chemistry: protolichesterinic acid (medulla K-, KC-, Pd-, C-)

The species is similar to M. eperforata but differs in its medullary chemistry, colour of the upper surface, sparser, globular isidia, generally smaller, more irregularly disposed lobes and in its habitat ecology (see p.45, couplet 74). M. minuta is an extremely rare endemic species known from two localities in north-western Tasmania. It occurs on the canopy twigs of Eucryphia lucida in

thamnic rainforest and is associated with Coccotrema cucurbitula, sooty mould and blue-green algae.

97. Menegazzia nothofagi (Zahlbr.) P. James & D. Galloway

See Galloway (1985) for a full description. The species resembles M. eperforata in general appearance and chemistry but differs in the presence of perforations, the absence of isidia and the presence of laminal pustules which become abraded and sorediate (see also p.46, couplet 80). M. nothofagi is common and widespread in Tasmania, mostly in lowland areas, and ranges from epiphytic habitats in wet forest to saxicolous or terricolous habitats in coastal heath and dry sclerophyll forest. Saxicolous individuals are very variable and are often browner, with more swollen upturned lobes. Their pustules may become very well-developed, elevated and contorted before they become sorediate. In rainforest, the species is more uniform and occurs either directly on rough or smooth bark, or over epiphytic bryophytes. It is usually found in the middle height zone of tree trunks, associated with species of Psoroma and Pseudocyphellaria. Menegazzia nothofagi is also known from Australia and New Zealand.

98. Menegazzia platytrema (Müll. Arg.) R. Sant.

Thallus rosette-forming, to 20 cm diam., lobes 2-3 mm wide. Upper surface pale ± creamy grey, smooth to faintly rugose. Perforations c. 1-1.5 mm wide, the edges turned inwards. Apothecia to 6 mm diam. Spores 2/ascus, (34-)42-58 x (20-)25-35 µm, with walls to 3.5 µm thick.

Chemistry: atranorin, stictic acid complex, menegazziaic acid, ± norstictic acid (trace), ± UV+ purple unknown (medulla K+ yellow, Pd+ orange)

The species superficially resembles M. weindorferi (below) and its diagnostic features are discussed under that species (see also p.47, couplet 88). M. platytrema is widespread in rainforest where it is mostly confined to canopy twigs in association with Coccotrema cucurbitula, Lecidea laeta and Usnea spp. It becomes increasingly common outside rainforest and is often a dominant epiphyte on smooth bark in both wet and dry sclerophyll forests. Here it is commonly associated with Parmelia subrudecta, P. perlata and several crustose species. M. platytrema is also known from Australia.

99. Menegazzia retipora (Stirton) Bitter

Thallus rosette-forming, mostly to 5 cm across. Lobes 0.5-1 mm wide, crowded and imbricate in the centre of the thallus, with ± flattened tips. Upper surface pale grey, smooth, shining. Perforations mostly very numerous, ± forming a reticulum, to 0.5 mm across, edges flush or turned inwards. Apothecia numerous, to 3 mm diam. Spores 2/ascus, 45-53 x 24-31 µm.
Chemistry: atranorin, stictic acid and associated substances, ± gyrophoric acid

M. retipora is a common Tasmanian endemic species, widespread on canopy branches and twigs in callidendrous and thamnic rainforest. It is usually associated with M. weindorferi, Pannoparmelia angustata, Usnea arida and Hypogymnia spp. The species is rare outside well-formed rainforest communities.

The unpublished name, M. prototypica P. James, was applied by Kantvilas et al. (1985) to a curious form of this species in which the perforations are very few, small and scattered. Field observations now suggest this form may be a response to shade.

100. Menegazzia subbullata P. James ined.

Thallus irregular in outline, sorediate. Lobes 2.5-4 mm wide, ± terete, inflated and pipe-like, pale grey, smooth or weakly wrinkled on the upper surface, with ± brownish tips, often with overlapping or discrete, short adventitious lobes and black streaks along the margins. Perforations occasional, 0.5-1 mm wide, edges usually turned outwards. Soralia developed at the tips of the lobes, unevenly on the margins of the perforations or superficially. Apothecia very rare, to 2 mm wide, ± clustered, with a very thick, inrolled, corrugated margin c. 0.5 m wide. Spores 2/ascus, 33-40 x 26-29 µm, with walls 3-4.5 µm thick, mature spores very rare.
Chemistry: atranorin, stictic acid (medulla K+ yellow, Pd+ orange)

M. subbullata is a common endemic species, widespread in subalpine and alpine vegetation. It is typically associated with Coccotrema cucurbitula, Menegazzia bullata, M. testacea, Ochrolechia sp., Pertusaria nothofagi, Sphaerophorus tener, Usnea arida and U. capillacea. It frequently occurs as a few ± dispersed, pipelike lobes, interspersed with other species of Menegazzia, and is therefore easily overlooked. The species is rare in rainforest and is confined to the canopy twigs of high altitude communities. M.

subbullata is distinguished from other grey sorediate species, e.g. M. ultralucens and M. inactiva, by its much broader, terete lobes and by the presence of stictic acid in the medulla. Neither of these species is known to co-occur with M. subbulata in its typical high altitude habitat (see also p.46, couplet 81).

101. Menegazzia subpertusa P. James & D. Galloway

See Galloway (1985) for a full description and p.47, couplet 83, for diagnostic features. M. subpertusa is a sorediate, pale whitish grey species with 2-spored asci. It is extremely rare in rainforest but is very common on trees and rocks in sclerophyll forests and coastal heath where it is commonly associated with M. platytrema, Parmelia pruinata, P. subrudecta, P. perlata and P. rutidota. In earlier literature on Tasmanian lichens [see Wetmore (1963)], M. subpertusa was referred to as M. diatrypa and M. pertusa (= M. terebrata, a Northern Hemisphere species). The species is also known from Australia and New Zealand.

102. Menegazzia testacea P. James & D. Galloway

See Galloway (1985) for a full description and p.47, couplet 85, for diagnostic features. M. testacea is a common alpine species found mostly on twigs but rarely also on sedimentary rocks in south-western Tasmania (e.g. Western Arthur Range). It is rare in rainforest and occurs mainly in the canopy of very high altitude communities or on understorey twigs in open montane forest. In very exposed situations, the characteristic red-brown colour may be bleached grey and the species resembles M. platytrema, although even bleached specimens retain some hint of reddish-brown along the lobe margins and apices. Moreover, M. platytrema is not an alpine species and lacks the ± shortly pedicellate apothecia characteristic of M. testacea. M. testacea occurs also in New Zealand where the species contains hypostictic and hyposalazinic acids (medulla K+ yellow->red) (Galloway 1985) in addition to atranorin and stictic acid which are present in Tasmanian material.

103. Menegazzia ultralucens P. James & D. Galloway

See Galloway (1985) for a full description and p.47, couplet 84) for diagnostic features. The species is rare in Tasmania and known from a few fragmented, sterile collections from canopy twigs in rainforest. It is also present in New Zealand.

104. Menegazzia weindorferi (Zahlbr.) R. Sant.

This species is similar to M. platytrema (above) but is easily recognised by several key characters (see p.47, couplet 88). In addition, the apothecial margins of M. weindorferi are marked by faint radial lines, and they become scabrid or discolour brownish, whereas in M. platytrema they are uncoloured and at most have a few radial cracks. The lobes of M. weindorferi are shorter, more crowded and ± imbricate, particularly in the centre of the thallus whilst in M. platytrema, they are more elongate and discrete. M. weindorferi is glossy, with almost a bluish tinge of pale grey and is abundantly stippled with black pycnidia. M. platytrema is matt, creamy-grey and with few pycnidia. The asci of M. weindorferi are 8 spored and its spores are 32-36 x 17-22 µm.

M. weindorferi is the most common rainforest species of Menegazzia. It is one of the dominant epiphytes of smooth-barked canopy branches and is usually associated with Parmelia tenuirima, P. testacea, Usnea arida and Pertusaria nothofagi. In more open forests, particularly at subalpine altitudes, the species ranges from the forest floor to the canopy. M. weindorferi is closely related to the New Zealand endemic species, M. pertransita, and the record of the latter species from Tasmania by Jatta (1910) is erroneous.

105. Micarea mutabilis B. Coppins ined.

Thallus effuse, consisting of ± scattered or contiguous aereolae, green to greyish-green. Photobiont cells ± spherical, 3.5-6 µm diam. Apothecia convex, immarginate, abundant, mostly c. 0.3-0.5 mm diam., pale fawn to dark brown to black, some fruits variably coloured and piebald. Darker apothecia with hypothecium dark purple-brown, greenish in K (just perceptible in pallid fruits). Hymenium partly dilute greenish or with greenish vertical streaks, K+ green intensifying. Spores hyaline, acicular, sigmoid, with ± rounded ends, generally broader at one end, (3-)5-7 septate, 28-41 x 3.5-4.5 µm.

Chemistry: thallus and apothecia C+ orange-red (faint) in squash preparations (gyrophoric acid?)

M. mutabilis is locally common in rainforest at Little Fisher River but may well have been overlooked elsewhere. The species occurs mostly on mature fissured trunks of Nothofagus, either over mosses or directly on bark. It prefers moderately dry habitats, intermediate between very dry aspects inhabited by Lecanactis abietina, Sagenidium etc., and very moist aspects inhabited by Sphaerophorus spp. and bryophytes. However, in younger or more open regions of the forest, it may be one of the dominant epiphytes on the driest, overhanging surfaces of the trunk. Commonly associated species include Conotremopsis weberiana, Sphaerophorus ramulifer and the moss, Leptotheca gaudichaudiana.

Material of M. mutabilis has been examined by Dr. B. Coppins who provided some of the descriptive data presented above. He also observes that, although quite different internally, the species superficially resembles M. peliocarpa. Its pallid apothecia are similar to those of M. globusella but that species has shorter spores (13-26 µm long). Moreover, the pigments of the darker apothecia of M. mutabilis are quite different and, instead, are the same as those found in M. sylvicola and M. melaena (B. Coppins, pers. comm.).

106. Micarea prasina Fr. aggr.

Thallus of discrete, ± spherical granules (goniocysts), dispersed or forming a thick crust, bright green to greyish (usually fading to grey in the herbarium). Photobiont cells 3-5 µm diam. Apothecia to 0.3 mm diam., immarginate, convex to ± subglobose, rarely adnate, smooth or tuberculate, mostly milky white, occasionally fawn. Hymenium colourless, K- or (rarely) K+ fleetingly faint violaceous. Paraphyses anastamosing. Hypothecium colourless or pale yellow-brown, K-. Spores hyaline, rather variable, ovoid, oblong or ellipsoid, 0-1(-3) septate, 7-12 x 2.5-3.5(-4.5) µm.
Chemistry: thallus and apothecia K-, C- (macroscopically and in squash mounts)

This taxon is common and widespread throughout rainforest in Tasmania. It is found mostly on old, fissured Nothofagus trunks and ranges from very dry aspects, where it occurs directly on bark, to

moist aspects where it may also overgrow bryophytes. More rarely the species is found on decorticated wood or on smooth bark.

M. prasina aggr. exhibits a wide range of variation in Tasmania and there may be several species of this complex aggregate present in Tasmanian rainforest. In this account, all specimens with a goniocyst-type thallus, mostly hyaline apothecia internally, K-, C- throughout, and with spores as denoted above are combined under M. prasina. A common form of the species has the goniocysts dispersed over a thin, black, prothallus-like film. An additional goniocyst-type species (not included here) has red-brown apothecia (superficially and internally) which are C+ red in squash preparations. A detailed account of M. prasina s. str. is given by Coppins (1983).

107(a). Mycoblastus sp.1

Thallus crustose, thick, granular, scurfy or aereolate, pale whitish to yellowish grey, rarely dull olive-grey, with a black prothallus sometimes present at the margin. Soredia usually present, scattered and diffuse, mostly arising from abrasion of the granules. Apothecia lecideine, to 1.5 mm diam., immarginate, markedly convex to subglobular. Disc brown-black, rarely with a greenish tinge in younger apothecia, mostly rough and uneven. Epithecium bluish green, K+ pale greenish grey. Hymenium pale brown, colourless in K. Hypothecium pale brown, sometimes with a bluish green band below, turning colourless in K, rarely K+ yellowish in the lower parts. Spores (1-)2(-3)/ascus, simple, hyaline, ellipsoid, 38-72 x 20-36 µm, with walls 3-6 µm thick.
Chemistry: perlatolic acid(?) (main substance), ± atranorin, ± several unknowns (medulla and soralia UV+ bluish white, K± yellow-orange (faint), Pd- or + faint orange, C-)

Mycoblastus sp.1 is common and widespread in most rainforest communities where it occurs on rough, smooth or fibrous bark, particularly on such phorophytes as Phyllocladus, Nothofagus gunnii and Leptospermum lanigerum. Commonly associated lichens include Megalospora lopadioides and Austroblastenia pauciseptata. The species is mostly found in clearings, on the middle portions of trees or beneath a broken or sparse forest canopy.

Mycoblastus sp.1 is extremely variable but the internal colours of the apothecia (with and without K) are diagnostic. Specimens with

a dull olive-grey thallus are typically esorediate (or almost so) and occur in exposed habitats. One chemical variant is distinguished below. The New Zealand endemic species, M. hypomelinus, is similar but the single specimen of that species which was examined (Knight 305) differed in its more verrucose, esorediate thallus, UV- medulla and the presence of fumarprotocetraric acid(?) as the major chemical constituent (thallus Pd+ orange-red).

107(b). Mycoblastus sp.1 (variant B)

Similar to the above species but with a different chemistry which includes fumarprotocetraric acid(?), atranorin(?) and several unknowns. The soralia and medulla are Pd+ red, UV+ blue-white. The spores are a little smaller, 31-39 x 17-20 µm, but specimens of this taxon are only scantily fertile and few spores were seen. The internal colours of the apothecia are like those of 107(a). This entity is known only from rainforest at Little Fisher River where it co-occurs with Mycoblastus sp.1 on well-lit trunks and young branches of Nothofagus cunninghamii.

108. Mycoblastus sp.2

Thallus crustose, rather thin, aereolate, mottley slate-grey, esorediate. Apothecia lecideine, to 1 mm diam., convex, immarginate. Disc black, shiny, uneven. Epithecium deep purple-violet, K+ brilliant blue-green. Hymenium pale brown, colourless in K. Hypothecium pale brown, sometimes with a dull blue-green band beneath. Exciple ± dull blue-green. Medulla beneath hypothecium colourless, K+ golden-yellow. Spores 2/ascus, hyaline, simple, ellipsoid, 40-60 x 24-31 µm, with wall 2-5 µm thick.
Chemistry: perlatolic acid(?) ± several unknowns (thallus and medulla K-, Pd-, C-, UV-)

Mycoblastus sp.2 is rare and known in Tasmania from three widely separated rainforest localities. It has been found in the canopy of Nothofagus cunninghamii, associated with Lecidella elaeochroma, Coccotrema cucurbitula, Fuscidea sp. and other crustose lichens. The distinctive colour reactions in K of the internal parts of the apothecia are the same as those reported by James (1971) for Mycoblastus fucatus, a sorediate European species which contains fumarprotocetraric acid.

A further species of Mycoblastus is known from alpine heath at Hartz Mts, Tasmania. Like Mycoblastus sp.1, this additional species has a dull olive-grey thallus with a UV+ blue-white medulla. However, the epithecium is blue-green, K+ yellow, whilst the remainder of the apothecium (in section) is pale brown, K+ vivid blood-red.

109. Nephroma australe A. Richard

A full description is given by Galloway (1985). For diagnostic features, see p.51, couplet 106. N. australe is common and widespread in wet forest, scrub and heath. In rainforest, it mostly occurs on the canopy twigs of subdominant trees, on low branches or on shrubs in clearings. It is commonly associated with species of Pseudocyphellaria and Psoroma. The species is also known from New Zealand and Australia. The record of N. antarcticum from Tasmania by Wilson (1893) most probably refers to N. australe.

110. Nephroma cellulosum (Sm. in Ach.) Ach.

See Galloway (1985) for a full description and p.51, couplet 106, for diagnostic features. N. cellulosum is a common species in wet sclerophyll forests, wet scrub or at the margins of rainforest. It is particularly well-developed on shrubs of the Compositae where it is associated with Sticta limbata, S. sublimbata and species of Pannariaceae and Collemataceae. It is rare in rainforest and occurs mostly on low twigs of various phorophytes or on the buttresses of species of Eucalyptus subgen. Symphyomyrtus. Nephroma cellulosum is also known from Australia, New Zealand and southern South America. The closely-related, isidiate species, N. lepidophyllum, is also known from Tasmania (Galloway 1985) but has not been recorded in rainforest.

111. Ochrolechia sp.

Thallus crustose, whitish grey, thin and patchy (on young twigs) to continuous and aereolate (on older branches). Apothecia lecanorine, to 1.5 mm diam. Thalline margin prominent, inrolled. Disc concave to plane, orange-pink, usually densely white pruinose. Spores simple, hyaline, 4-8/ascus, ovate to broadly ellipsoid, 38-60 x 19-29 µm.

Chemistry: thallus K- or K+ faint yellow, C-, KC-, Pd-; apothecial disc C+ red, KC+ orange-red, K-, Pd-

The species is common on canopy twigs and young branches in wet forests from lowland to alpine altitudes. It is typically very small, rarely > 2 cm across, and is commonly associated with Usnea spp., Pertusaria nothofagi and Haematomma infuscum. Ochrolechia sp. is still very poorly known and requires further collection and study. It does not correspond to any New Zealand species mentioned by Galloway (1985). On the basis of habitat notes and a short diagnosis (see Jatta 1910), O. weymouthii (described from Atherosperma on Mt. Wellington, Tasmania) could be a possible name.

112. Opegrapha stellata Knight

Thallus crustose, pale grey to greenish grey, very thin, sometimes evanescent, often with a marginal black prothallus to 4 mm wide. Apothecia lirelliform, with a black, raised proper margin ± totally obscuring the disc, c. 1-4 mm long, simple or branched, straight or curved, dispersed or crowded, commonly in star-shaped clusters. Epithecium and exciple brown-black, K-. Hymenium and hypothecium colourless. Paraphyses netted. Spores simple, hyaline (very rarely brownish), 8/ascus, ovate to ellipsoid, with rounded ends, (7-)10-12(-14) x (3-)4-7 µm.

Chemistry: norstictic acid (sometimes in trace amounts only); a spot test with Pd or K is mostly unreliable because the thallus is so thin.

O. stellata is a common pioneer species of twigs and young trunks within rainforest (i.e. not in the canopy) and is commonly encountered on Trochocarpa gunnii or Anodopetalum. In open habitats, its thallus is whitish grey whilst in the shade, the thallus tends to be greenish to almost absent. Most lirellae sectioned did not contain mature spores despite the seemingly good development of the specimens. O. stellata is a new record for Tasmania and was previously considered endemic to New Zealand (Galloway 1985). Further data on the species are given by Hayward (1977).

113. Pannaria immixta Nyl.

A full description is given by Galloway (1985). Diagnostic features are given on p.49, couplet 94. P. immixta is recognised by its gyrose-etched apothecial disc. Spores in Tasmanian material are 12-17 x 6-7.5 µm and have a smooth epispore c. 0.5-1 um thick. The hymenium is I+ blue-green in part, the colour fading only a little.

Parts of the hypothecium are I+ very pale violet. The species is very rare in Tasmania and known from a single small collection from understorey twigs in callidendrous rainforest in the Arve Valley, southern Tasmania. It also occurs in New Zealand.

114. Pannaria sp.

Thallus squamulose, pale lead grey, forming rosettes to c. 5 cm across, closely adnate over a black prothallus. Squamules thin, well-developed at the margins, becoming imbricate, cracked, subcrustose in the centre of the thallus. Apothecia lecanorine, to 1 mm diam., scattered, sometimes in groups of 2 or 3 confluent fruits. Disc smooth, ± plane, pale orange-brown, sometimes ± blackened. Thalline margin thin, crenulate, radially cracked, often with small gaps. Proper margin thin, mostly ± concolorous with the disc, often obscured by the thalline margin. Spores simple, hyaline, ellipsoid, 12-15 x (4.5-)6-7.5 µm, with epispore c. 1-1.5 µm thick, ± smooth to minutely roughened. Hymenium I- or in part faint blue, fading rapidly to yellow-brown.

This species is very similar to P. immixta but differs in its smooth apothecial disc (see p. 49, couplet 94). It is also similar to those forms of Parmeliella nigrocincta (see below) in which the lecideine apothecia are partially enveloped by squamules. However, both this species and Pannaria immixta differ from Parmeliella nigrocincta in their pale lead-grey rather than dark blue-grey colour. Pannaria sp. is known from several rainforest localities where it occurs on smooth bark in deep shade.

115. Pannaria aff. pezizoides (G.H. Web.) Trevis.

Thallus squamulose, dull dark grey to brown-grey. Squamules thick, crenate-lobulate, densely imbricate, undulate to ± ascending. Apothecia lecanorine, usually crowded and almost contiguous, to 2 mm diam. Disc plane to convex, dark reddish brown to black-brown. Thalline margin thick, crenulate-lobulate, complete and ± totally obscuring the proper margin, sometimes encroaching on the disc. Spores simple, hyaline, ovate to broadly ellipsoid, 12-17(-20) x 7-10 µm, with epispore to c. 2 µm thick, mostly conspicuously warted and slightly thicker at the apices. Hymenium I- or I+ blue-green, fading rapidly to pale yellow-brown.

The species is frequent in Tasmania at the margins of wet forests. It occurs on the thick or fibrous bark of some eucalypts, Leptospermum lanigerum and Cassinia aculeata and is commonly associated with species of Psoroma, Leptogium and Collema. Pannaria aff. pezizoides is recognised by its thick, dark squamules and reddish-brown, large apothecia (see also p.48, couplet 93). Tasmanian material differs from the European species, P. pezizoides s. str. [described in Jørgensen (1978)], in its smaller spores and by the I- reaction of the hymenium. In the European taxon, the hymenium is I+ persistent blue and the spores are 25-30 x 9-12 µm (counting the epispore).

116. Pannoparmelia angustata (Pers. in Gaud.) Zahlbr.
= Anzia angustata (Pers. in Gaud.) Müll. Arg.
= Parmelia inaequalis Taylor
= P. moniliformis J.D. Hook.

See Galloway (1985) for a full description and p.52, couplet 115, for diagnostic features. Bratt et al. (1976) discuss the species in Tasmania. P. angustata is common and widespread in high rainfall areas in Tasmania, ranging from sea-level to subalpine altitudes. In rainforest, it is a typical canopy twig species, usually associated with species of Usnea, Hypogymnia and Menegazzia. It is best developed in callidendrous rainforest and is rare or absent from forests with broken canopies. The species also occurs in Australia and New Zealand. The record of Anzia colpodes from Tasmania by Wilson (1893) refers to Pannoparmelia angustata.

117. Parmelia cunninghamii Crombie

See Galloway (1985) and Galloway and Elix (1983) for a full description and p.53, couplet 120, for diagnostic features. The species is widespread in Tasmania and is recognised by its broadly rounded, marginally sorediate lobes and the presence of salazinic acid in the medulla. Pseudocyphellae are rather scarce in some specimens. In rainforest, P. cunninghamii occurs in well-lit habitats, usually on the main branches of the canopy, and is associated with P. tenuirima, Menegazzia weindorferi and Pertusaria nothofagi. It occurs also in dry sclerophyll vegetation. The species is known from Australia, New Zealand and Fuegia.

118. Parmelia labrosa Zahlbr.

See Galloway (1985) for a full description (under Pseudoparmelia) and p.54, couplet 125, for diagnostic features. Tasmanian material has larger spores (12-14.5 x 7-9.5 µm) than those given by both Galloway (op. cit.) and Hale (1976a) (i.e. 10-12 x 5-8.5 µm). The species is known in Tasmania only from rainforest at the Little Fisher River but may well have been overlooked elsewhere. It occurs on canopy twigs and young low branches in clearings, usually as small, juvenile thalli, < 2 cm wide. The separation of such specimens from the more common and rather similar species, P. cf. revoluta, can be difficult. P. labrosa is also known from Australia, New Zealand and Chile.

119. Parmelia perlata (Huds.) Ach.

See Galloway (1985) for a full description (under Parmotrema) and p.53, couplet 122, for diagnostic characters. This species is common in Tasmania, particularly on solitary trees in pasture and on rocks in dry sclerophyll forest where it is associated with P. signifera. It is rare in rainforest where it occurs on bark or wood, mostly in "mixed forest" or in rainforest gullies in eucalypt forest. P. perlata is superficially similar to P. reticulata which differs chemically (salazinic acid, medulla K+ yellow → red), has a reticulately cracked upper surface and which is unknown from within the range of rainforest vegetation. P. perlata is cosmopolitan.

120. Parmelia protosulcata Hale

See Galloway and Elix (1984) for a full description and p.53, couplet 120, for diagnostic features. P. protosulcata is a rare canopy twig species known from two rainforest localities where it was associated with species of Menegazzia and Usnea. It is also known from Australia, New Zealand and Fuegia.

121. Parmelia pruinata Müll. Arg.

See Galloway (1985) for a full description (under Parmelina) and p.53, couplet 123, for diagnostic features. P. pruinata is a very variable species, whitish to pale lead grey, with lobes ranging from broadly rounded to narrow, elongate and dissected. It is widespread from sea-level to alpine altitudes but is most common in dry sclerophyll vegetation on Acacia, Casuarina and Bursaria. The species

is very rare in rainforest and is confined to canopy twigs, mostly in "mixed forest" or rainforest gullies in sclerophyll forest. It is typically very poorly developed and may closely resemble juvenile thalli of P. cf. revoluta. Small, apparently esorediate thalli should be checked carefully for incipient development of soralia which would indicate they are the latter species. P. pruinata is also known from Australia and New Zealand.

122. Parmelia cf. revoluta Flörke

Thallus foliose, upper surface white-grey, lower surface black. Lobes ± adnate, flat to convex, to c. 4 mm wide, with mostly revolute apices and sinuate axils. Margins of lobes sparingly ciliate or with horizontal rhizines, particularly in the axils, frequently with a very thin black border. Soralia developing from laminal or subapical pustules, inconspicuous in small or juvenile thalli. Apothecia extremely rare, ± subpedicillate, to 3 mm diam. Thalline margin smooth or rugose-sorediate. Spores 12-16(-22) x 7.5-12 µm.
Chemistry: atranorin, chloroatranorin, gyrophoric acid and trace 5-O-methylhiascic acid (medulla C+ red) [analyses by J.A. Elix]

This species has affinities with the cosmopolitan lichen, P. revoluta (P. James per. comm.) [see Galloway (1985) under Hypotrachyna]. However, Dr. J. Elix (pers. comm.) suggests the Tasmanian taxon is closer to P. afrorevoluta (see Krog & Swinscow 1979). The presence of marginal cilia and horizontal rhizines in the Tasmanian material supports this view but the spores are smaller (spores of P. afrorevoluta are 20-22 x 10-14 µm) and instead fall within the size range for P. revoluta as given by Krog and Swinscow (op. cit.) and Hale (1975a). Thus the identity of the Tasmanian species remains in doubt.

P. cf. revoluta is a widespread epiphyte in high rainfall areas in Tasmania. In rainforest, it is mostly an occasional canopy species although it is also locally common on trunks in some rainforests in north-eastern Tasmania. The species is usually associated with species of Menegazzia and Parmelia.

123. Parmelia sinuosa (Sm.) Ach.

See Galloway (1985) for a full description (under Hypotrachyna) and p.52, couplet 115, for diagnostic characters. The species is widespread in well-lit habitats in high rainfall areas but is uncommon in rainforest and confined mostly to the canopy. It is found usually as small, juvenile thalli in which the characteristic capitate, apical soralia are poorly developed. P. sinuosa is cosmopolitan.

124. Parmelia subfatiscens Kurok.

See Hale (1976b) for a full description (under Parmelina) and p.53, couplet 124, for diagnostic features. The species is similar to P. cf. revoluta but differs in its medullary chemistry which includes only trace amounts of gyrophoric acid (medulla C- or C+ fleeting pink). Furthermore, when well-developed, it has exuberant laminal or subapical pustules which become abraded but not sorediate. P. subfatiscens occurs in similar habitats to P. cf revoluta but is markedly less common, at least in rainforest. It is also known from Australia, South Africa and the West Indies.

125. Parmelia subglabra (Räs.) Essl.

See Esslinger (1977) and Galloway (1985) [under Melanelia] for a full description and p.52, couplet 113, for diagnostic features. P. subglabra is widespread but uncommon on canopy twigs in rainforest, particularly at high altitudes. No fertile material is known from Tasmania. Thalli are seldom more than 2 cm across and the development of soralia is often very poor. The species is also known from southern South America and New Zealand.

126. Parmelia tenuirima J.D. Hook. & Taylor

See Galloway (1985) and Galloway and Elix (1983) for a full description and p.53, couplet 121, for diagnostic features. The species is a common and widespread epiphyte in well-lit habitats in high rainfall areas. In most rainforests, it is found on the main axes of the canopy, although in more open, lower or younger forests it may extend to the bases of the trunks. It is commonly associated with Menegazzia weindorferi, Pertusaria nothofagi and Parmelia testacea. The species is very similar to P. testacea (see below), and to P. signifera, a widespread saxicolous or terricolous species with

thicker, coarser, often blackened lobes. P. tenuirima is also known from Australia and New Zealand.

127. Parmelia testacea Stirton

See Galloway (1985) for a full description and p.53, couplet 121, for diagnostic features. Chemical and morphological variation in P. testacea is discussed by Galloway and Elix (1983) and most Tasmanian specimens belong to chemodeme II of these authors (loc. cit.) (i.e. atranorin, chloroatranorin, salazinic acid + unknown substance, medulla K+ yellow→red). The different chemical strains may be given species status in the future (M.E. Hale pers. comm.). P. testacea is a common wet forest species in habitats similar to P. tenuirima. It is most abundant at high altitudes and is frequently the dominant macrolichen in subalpine low woodland and rainforest scrub.

128. Parmeliella nigrocincta (Mont.) Müll. Arg. aggr.

Two recognisable morphotypes of this complex and very variable species aggregate are outlined below.

(a) Thallus squamulose, dark blue-grey. Squamules very variable, ± discrete and dispersed over a black prothallus or crowded and contiguous, well-defined and radiating at the thallus margin, cracked and subcrustose in the centre, deeply incised, usually with small marginal lobules or subterete, ± coralloid, branched, ascending isidia. Apothecia lecideine, to 1 mm diam. Disc pale orange to pale brown, plane to convex. Proper margin thin, pale fawn. Hymenium I- or I+ bluish green, fading rapidly to pale yellow-brown. Spores simple, hyaline, ovate to ellipsoid, 9-18(-21) x 6-9(-11) µm, with a distinct epispore, very minutely to markedly warted.

This is the most common rainforest morphotype. It occurs in deep shade, typically on understorey twigs. It appears to be confined to rainforest.

(b) Similar to the preceding morphotype but differing in the following characters:
- hymenium I+ blue, colour persistent
- apothecial disc red-brown, occasionally blackened

- squamules adnate throughout, crenulate - lobulate but not isidiate.

This form occurs on bark, rocks, mosses or decorticated wood in deep shade in rainforest, scrub, sclerophyll forest and coastal vegetation. Although very variable across its range, within rainforest it is quite distinct from morphotype (a).

In both morphotypes but particularly in (b), the lecideine apothecia may be partially enveloped by thalline squamules, making confusion with a Pannaria possible. However, at least some unenveloped fruits are usually present. Moreover, the colour of Parmeliella nigrocincta is typically dark blue-grey and different from the pale lead-grey of the morphologically similar Pannaria species. Thallus colour is a useful guide to identifying sterile thalli (see also p. 48, couplet 92). Additional data on Parmeliella nigrocincta are provided by Galloway (1985). Jørgensen (1978) observes that the species has an I+ persistent blue hymenium. On that basis at least, his concept of the species accords best with morphotype(b). P. nigrocincta is also known from New Zealand, South America, Tristan da Cunha and Australia. Earlier records of P. triptophylla and P. microphylla from Tasmania probably refer to P. nigrocincta.

129. Peltigera dolichorhiza (Nyl.) Nyl.

See Galloway (1985) for a description and p.50, couplet 104, for diagnostic characters. The species is very common and widespread on soil, rocks, bark, wood and charcoal. It is commonly found amongst bryophytes in moist, usually shaded habitats in forest or at the forest margins and is often the first macrolichen to re-establish after forest fire.

In rainforest, P. dolichorhiza is locally common in callidendrous and thamnic communities on logs, tree buttresses, peat mounds, mossy rocks and the trunks of Dicksonia antarctica. It is commonly associated with Pseudocyphellaria dissimilis. The species is also known from Australia and New Zealand and is considered palaeotropical by Galloway (1985). Earlier reports of P. polydactyla from Tasmania (Wetmore 1963) probably refer to P. dolichorhiza. The species is variable both chemically and morphologically, particularly in the degree to which the lobes are divided. In general, specimens

growing in the open are ± dark reddish-brown and with crowded, incised lobes. Specimens from forest have loosely overlapping, broadly undulate, blue-green lobes. There is also a rare, unidentified species in wet forests which has squamiform marginal and laminal isidia.

130. Pertusaria cf. nothofagi Zahlbr.

Thallus crustose, pale greyish white, sordid grey or very pallid olive-grey, rather thick and cracked, with roundish to ± irregularly lumpy, sessile verrucae to 2 mm across which become fissured, eroded, exfoliating, white sorediate. Apothecia immersed singly in verrucae. Disc obscured at first, concave to plane, pale orange-brown to grey, densely white pruinose. Spores 8/ascus, simple, hyaline, ovate to ellipsoid, often with ± blunt acuminate apices, 16-27 x 8-14.5 µm.
Chemistry: includes picrolichenic acid (medulla and apices of verrucae KC+ pink, K+ dull orange-yellow)

P. cf. nothofagi is extremely common and widespread in rainforest from lowland to alpine altitudes and occurs in well-lit habitats on smooth bark, particularly on young Nothofagus cunninghamii. In tall closed forests, it is confined to the canopy but in lower, younger or more open communities, it may extend down to the base of the trunk. The species is commonly associated with grey species of Parmelia and Menegazzia. It is very similar to Pertusaria cf. novaezelandiae (see below) and is most easily identified by the KC+ pink reaction of the medulla.

There is some uncertainty regarding the identity of this species. In the original description of P. nothofagi (Zahlbruckner 1941), the spore size is given as 18-29 x 6-12 µm and accords with that of Tasmanian specimens. However, Galloway (1985) re-examined the type material and found much larger spores (43.5-74 x 26.1-38.8 µm). On the basis of his account, the Tasmanian taxon would correspond best with P. truncata Krempelh., a related New Zealand endemic species. Neither of these two species of Pertusaria have been recorded previously from Tasmania and at present the identification of the Tasmanian species is provisional.

131. Pertusaria cf. novaezelandiae Szatala

Thallus crustose, greyish-white to pale glaucous grey, thick, wrinkled, cracked, with apically sorediate papillae and verrucae. Verrucae to 2 mm wide x 1 mm tall, cylindrical to subglobular or with a broader base and appearing squashed, sometimes confluent in groups of 2-4, white sorediate-pulverulent at the apices and ultimately becoming ± excavate. Apothecia rare, immersed deeply in the verrucae, obscured by a dense sorediate "plug", hymenia usually eroded. Spores 1/ascus, simple, hyaline, ellipsoid to cylindrical, sometimes a little curved or broader at one end, (52-)84-150 x (14-)22-48 µm, wall to 5 µm thick.

Chemistry: hypothamnolic acid (medulla and soredia K+ dark purple)

At present, P. novaezelandiae is known only from the type specimen (from New Zealand) in which the verrucae contain no hymenial elements (Galloway 1985). Hence the identification of the Tasmanian material is provisional and based only on morphological and chemical data (see Galloway op.cit.) In the majority of Tasmanian collections, the hymenium is badly eroded, absent or deeply immersed so that to find spores requires almost "hit-and-miss" sectioning.

Unfortunately this species was recognised only in the final stages of the project and was previously misdetermined as P. nothofagi. It is common in north-eastern Tasmania and has probably been overlooked elsewhere. It occurs in habitats identical with P. nothofagi and both species can be sympatric. Macroscopically, they are very alike, to the extent that chemistry provides the quickest reliable means of identification. However, on the available material, P. cf. novaezelandiae has a thicker, more wrinkled, more glaucous thallus. Its verrucae have squashed, broad bases rather than constricted bases. In P. nothofagi, the verrucae are never confluent. The papillae, which are mostly incipient verrucae, are also characteristic of P. cf. novaezelandiae.

132. Pertusaria sp.1

Thallus crustose, pale green-grey to grey, thin, ± maculate, often ± discontinuous, esorediate. Apothecia lecanorate, to 0.5 mm diam., very pale, almost translucent. Disc very pale fawn, concave. Spores 2/ascus, simple, hyaline, 25-36 x 14-17 µm.

Chemistry: thallus K+ yellow, C-, Pd-, KC-

The species is very rare and known only from Little Fisher River. It occurs mostly on mature trunks of Nothofagus, typically on moist, bare areas of bark in between lush growths of Sphaerophorus spp. and bryophytes. Less commonly it may be found in drier habitats associated with Micarea spp. The species is extremely inconspicuous and its translucent apothecia resemble those of a Thelotrema.

133. Pertusaria sp.2

Thallus crustose, thick, whitish grey, occasionally ± glaucous, spreading unevenly in large patches to 20 cm across. Apothecia immersed in thalline, ± cylindrical papillae, to c. 3 mm tall x 1 mm diam., with rounded, somewhat enlarged tips, occasionally ± eroded, outer wall sometimes cracked and partially exfoliating. Spores simple, hyaline, 1/ascus, broadly ellipsoid, ovate to ± spherical, 100-175 x 70-125 µm, discharged in a gelatinous matrix. Gel translucent grey or pale orange-pink to the naked eye, not dissolving in K. Spore wall single(?), to 25 µm thick.
Chemistry: protocetraric acid (medulla Pd+ red)

Mature spores are rare and most specimens are abundantly papillate but with little or no hymenial development within. Hence the morphology of asci, paraphyses etc. could not be observed. On maturity, a pinkish orange gel containing the spores is exuded through the eroded tips of the papillae.

Pertusaria sp.2 is common and widespread in implicate rainforest in south-western and western Tasmania. It encrusts epiphytic bryophytes, bark and litter on low branches and trunks. The species is characteristic of this rainforest type and is usually associated with Sphaerophorus scrobiculatus, S. melanocarpus, Siphula spp. and leafy hepatics. It ranges from lowland to alpine altitudes and is also known from very wet, fire-protected, mossy rock fissures in the mountains of south-western Tasmania (e.g. Western Arthur Range).

134. Phaeographis exaltata (Mont. & v.d. Bosch) Müll. Arg.

Thallus crustose, grey to creamish grey. Lirellae usually serpentine and branched, sometimes short, roundish and interrupted by thallus, clustered or dispersed. Disc ± immersed, black or greyish pruinose, typically 0.3-0.5 mm wide. Spores 8/ascus, 22-38 x 10-12 µm, consistently 6-locular, becoming brown.
Chemistry: nil

P. exaltata is widespread and frequent in thamnic or implicate rainforest on trunks with smooth bark in moderate shade. Common phorophytes include Anodopetalum, Cenarrhenes and Eucryphia lucida. The species is a new record for Tasmania and is also known from New Zealand and the tropics (see also Galloway 1985).

135. Phlyctella subuncinata (Stirton) D. Galloway
= P. wilsonii Müll. Arg.

Thallus crustose, pale grey, very thin. Apothecia to 0.3 mm diam., ± immersed, single or clustered in groups of up to 6. Thalline margin and surrounding area dissolving into white soredia. Disc dark grey, densely white pruinose. Spores hyaline, fusiform, 7-septate, 40-53 x 4.5-7 µm.
Chemistry: stictic acid and other compounds (medulla and soredia K+ yellow, Pd+ orange)

See Galloway (1985) for a full description. P. subuncinata is common and widespread in callidendrous rainforest and wet sclerophyll forest where it occurs in shade on trees with smooth bark, particularly Atherosperma and Pomaderris apetala. It is a pioneer species and is commonly associated with Thelotrema lepadinum, Bacidia weymouthii and other crustose lichens. Well-developed, fertile specimens are uncommon but the lichen is easily recognised by the irregular, white sorediate-leprose patches which mark the position of the immersed apothecia. P. subuncinata is also known from Australia and New Zealand.

136. Phyllopsora congregans (Zahlbr.) D. Galloway

See Galloway (1985) for a full description and p.49, couplet 97, for diagnostic features. The species is widespread in rainforest above c. 700 m altitude and extends into subalpine and alpine habitats. It is found on rotting wood, very old bark or peat. In

rainforest, it usually occurs on mossy, decorticating buttresses or mature trunks of Nothofagus and is associated with Sphaerophorus spp. and Lecidea cf. granulosa. P. congregans differs from the latter species in its larger, redder, scabrid apothecia which may coalesce into irregular hymenial areas to 20 mm across. P. congregans also occurs in New Zealand.

137. Physma chilense Hue

See Galloway (1985) for a full description and p.43, couplet 61, for diagnostic features. The species has red-brown apothecia with white-grey pruinose, tomentose, crenate thalline margins. Its spores are simple, broadly ellipsoid to ± spherical, 12-16 x 10-12 µm, including a ± minutely warted epispore to c. 2 µm thick. P. chilense is very rare but widely distributed in Tasmania and occurs mostly on shrubs of the Compositae in scrubby wet sclerophyll vegetation. Associated lichens typically include species of Pannariaceae and Collemataceae. P. chilense is also known from New Zealand and southern South America.

138. Physma sp.

Thallus subfoliose, homoiomerous, dark olive-green, fenestrate, with dull olive-brown ridges beset with isidia-like warts and nodules when dry, swelling markedly when wet into a granular, pulvinate cushion c. 2 cm diam. Apothecia scattered, to 1 mm diam. Disc dark red-brown to blackish, concave to plane. Thalline margin prominent, granular-warted. Proper margin (in section) closed below, cupular, c. 100-125 µm thick. Hymenium I+ blue (weak). Spores simple, hyaline, ovate to ± spherical, 8-12 x 7.5-10 µm, with a distinct epispore to 1.5 µm thick.

The species is extremely rare and known from a single collection from the canopy of Eucryphia lucida in rainforest near the Arthur River, north-western Tasmania. This locality has since been clearfelled. Additional species of Collemataceae with simple spores are known from marginal rainforest situations such as wet scrub and heath dominated by Leptospermum or Melaleuca. These await further study and are not included in this account (see also Ramalodium).

139. Pilophorus conglomeratus F. Wilson

See Galloway (1985) for a full description and p.38, couplet 33, for diagnostic features. The species lacks cephalodia and is not a true Pilophorus, requiring transferrance to a separate genus (Galloway op.cit.). Some specimens possess numerous, terete, aborted or juvenile podetia to c. 2 mm tall which end in a spine. P. conglomeratus is common and widespread in rainforest in deep shade on mossy tree trunks and buttresses. It is commonly associated with Sphaerophorus spp., Cladia aggregata and the leafy hepatic, Bazzania adnexa. The species also occurs on peat in alpine or subalpine heath. Such specimens are usually yellowish or blackened, with highly branched, fissured pseudopodetia.

140. Placopsis gelida (L.) Lindsay

See Galloway (1985) for a description and p.48, couplet 89, for diagnostic features. The species is uncommon in rainforest and found mostly in bright light on disturbed earth at the forest margins, along road or track edges, or around uprooted trees. Associated species include Baeomyces spp., Stereocaulon ramulosum and the moss, Polytrichum juniperinum. Placopsis gelida is bipolar.

141. Polychidium sp.

See p.49, couplet 40, for diagnostic features. General features of the genus are given by Galloway (1985). No fertile material is known from Tasmania, making identification to species impossible. The species is rare and occurs in wet forests and heaths on bark or over epiphytic bryophytes. In shaded microhabitats, the branches are c. 3 cm long, pale blue-grey, extremely thin, lax and entangled, and become ± nodulose, papillate towards the tips. The papillae appear to be the initials of lateral branches. Main branches are often paler coloured and may be slightly wrinkled longtitudinally. In more exposed habitats, the branches are more robust, short and blackish to dark reddish-brown. This form may well represent a distinct entity.

In rainforest, Polychidium sp. is typically associated with species of Sphaerophorus, Siphula and Pseudocyphellaria. In wet heaths, the species is usually associated with Nephroma cellulosum and species of Collema and Leptogium.

142. Porina leptaleina (Nyl.) Müll. Arg.

Thallus effuse, grey-green, very thin. Perithecia hemispherical, mostly c. 0.25 mm wide, reddish-brown. Paraphyses simple, slender, c. 1 µm thick. Spores hyaline, 8/ascus, fusiform, with pointed ends, 3-septate, 21.5-29 x 3.5-5 µm.

The species is a new record for Tasmania and was previously considered endemic to New Zealand (see Galloway 1985). Tasmanian material consists of a single small specimen from Little Fisher River. The species occurred in deep shade on a rough, deeply fissured, decorticating buttress of Nothofagus cunninghamii. P. leptaleina is very similar to the European species, P. leptalea, and the only difference is the smaller spores (16-23 x 3-5 µm) of the latter (see Swinscow 1962). One small fragmented specimen from rainforest near Weldborough, north-eastern Tasmania, has spores 15-20 x 2.5-4.5 µm but the material is scanty and no conclusions on the status of these two species can be made.

143. Pseudocyphellaria ardesiaca D. Galloway

See Galloway (1985) for a full description and p.34, couplet 8, for diagnostic features. The species is rare in Tasmania and appears to be restricted to well-lit rainforest habitats such as the forest canopy or trunks in clearings. It is also known from New Zealand.

144. Pseudocyphellaria argyracea (Delise) Vainio aggr.

Thallus foliose, spreading to 10 cm diam., loosely attached, isidiate. Lobes to 10 mm wide, ragged, lacerate, leathery, elongate, concave, with margins ascending and apices rounded. Upper surface pale brownish grey to deep red-brown, with minute, scattered, punctiform pseudocyphellae. Isidia ± terete, knob-like, coralloid-branched, mainly marginal, or laminal and associated with the pseudocyphellae. Medulla white. Photobiont blue-green. Lower surface blackish to pale brown, tomentose, with prominent, white pseudocyphellae to 1 mm diam. Apothecia unknown.

P. argyracea is rare in Tasmania. It is found in well-lit habitats in rainforest, on twigs, canopy branches or on logs and trunks at the forest margins. The species is also known from Australia. It was erroneously referred to by Kantvilas et al. (1985)

as P. episticta, a New Zealand endemic species with a green photobiont.

145. Pseudocyphellaria billardieri (Delise) Räsänen

= Sticta flotowiana Laurer

= S. linearis J.D. Hook. & Taylor

= S. richardii Mont.

See Galloway (1985) for a full description and discussion. Further data are given in Galloway et al. (1983). Diagnostic features are summarised on p.35, couplet 18. The species is very similar to P. faveolata although in general, P. billardieri has neater, more elongate and regularly dichotomising lobes. The chemistry of the two species is distinctive (see Galloway et al. 1983). P. billardieri contains tenuiorin, methyl evernate, methyl lecanorate and other compounds and corresponds with Code C of Wilkins and James (1979). These substances appear as yellow-orange spots in standard, charred, t.l.c. analyses.

P. billardieri is a common and widespread epiphyte in wet forests in Tasmania. In rainforest, it is mostly confined to the middle regions of the tree although it may occur at lower levels in more open forests or in clearings. Commonly associated lichens include Psoroma microphyllizans and species of Pseudocyphellaria (including P. faveolata). P. billardieri can be extremely abundant in the semi-shaded, humid conditions of the understorey of a mature wet sclerophyll forest. The species is also known from New Zealand and Australia.

146. Pseudocyphellaria colensoi (Church. Bab.) Vainio

See Galloway (1985) for a full description and p.34, couplet 9, for diagnostic features. P. colensoi is common in rainforest in well-lit habitats on canopy twigs and branches. It also occurs on trunks or (rarely) rocks at the forest margin and in clearings. The species can attain a very large size (c. 30 cm diam.), is easily dislodged and hence commonly encountered in litter on the forest floor. P. colensoi is also known from New Zealand and Australia.

147. Pseudocyphellaria coronata (Müll. Arg.) Malme

= P. hirta (Stirton) D. Galloway & P. James

See Galloway (1985) for a full description and p.34, couplet 9, for diagnostic features. The species is similar to P. colensoi and is found in many wet heath and scrub communities as well as in wet forests. In rainforest, it is mainly a subcanopy twig species, often associated with Nephroma australe and Psoroma euphyllum. Like P. colensoi, it can attain sizes in excess of 30 cm across. In earlier literature (see Wetmore 1963), P. coronata was referred to as P. durvillei, P. endochrysa and P. orygmaea, all of which are synonyms of P. berberina, a South American species (see Galloway and James 1979). P. coronata is also known from New Zealand and the subantarctic islands.

148. Pseudocyphellaria crocata (L.) Vainio

= P. gilva (Thunb.) Malme

= P. mougeotiana (Del.) Vainio

See Galloway (1985) for a full description and p.34, couplet 12, for diagnostic features. P. crocata is a variable and ecologically wide-ranging species in Tasmania, occurring in bright light on wood, bark or rocks, often over bryophytes. The most prolific populations are found on rocks in sclerophyll forest where the species associates with Parmelia perlata, P. signifera and the related, phyllidiate species, Pseudocyphellaria neglecta. It is rare and poorly developed in rainforest where it is mostly confined to the canopy or to the forest margins. P. crocata is cosmopolitan.

149. Pseudocyphellaria delisea (Fée) D. Galloway & P. James

= Delisea pseudosticta Fée

= Sticta glabra J.D. Hook. & Taylor

See Galloway (1985) for a description and p.35, couplet 15, for diagnostic features. The species is very variable but is easily recognised by its pale yellow-green upper surface, black to dark brown lower surface and reddish brown apothecial disc. Contrary to the situation in New Zealand (see Galloway op. cit.), it is usually richly fertile, despite the abundant development of ± flattened or terete, usually branched, easily abraded isidia. Granular soredia have been observed in one specimen.

P. delisea is widespread in Tasmania throughout high rainfall areas. It occurs on rocks, peat, bark, wood or over bryophytes in heaths and forests from sea-level to alpine altitudes. In rainforest, it ranges from the forest floor to the canopy but is best developed on moist, shaded trunks. Commonly associated species include P. subvariabilis, Psoroma microphyllizans and species of Sphaerophorus. The physiological ecology of the species is discussed by Rundel et al. (1979). The numerous 19th Century records of Pseudocyphellaria freycinetii, a South American species, from Tasmania (see Wetmore 1963) refer to P. delisea. P. delisea is also known from Australia, New Zealand, the subantarctic islands and southern South America.

150. Pseudocyphellaria dissimilis (Nyl.) D. Galloway & P. James

See Galloway (1985) for a full description and p.35, couplet 14, for diagnostic features. P. dissimilis is a widespread and variable species with mainly marginal isidia and with entire or highly dissected, often phyllidiate margins. It is very common in wet sclerophyll forest and callidendrous rainforest where it occurs on rocks, soil, peat, logs, tree buttresses or tree-fern trunks. It is customarily associated with Peltigera dolichorhiza. Pseudocyphellaria dissimilis is also known from New Zealand and Australia.

151. Pseudocyphellaria faveolata (Delise) Malme

= Sticta cellulifera J.D. Hook.

= S. fossulata Duf. ex Nyl.

= S. physciospora Nyl.

See Galloway (1985) for a full description. The species is very similar to P. billardieri and distinguishing characteristics are summarised on p.35, couplet 18, and under no.145 (P. billardieri). The species has a distinctive chemistry which corresponds to Code B of Wilkins and James (1979). This includes physciosporin which appears as a grey-black spot in charred, standard t.l.c. analyses.

P. faveolata is common in Tasmania in wet forest and scrub in habitats similar to those of P. billardieri. However, it is marginally less shade-tolerant and is mostly confined to the middle to upper regions of trees, commonly associated with P. rubella, P. colensoi and Nephroma australe. P. faveolata is also known from New Zealand and southern South America.

152. Pseudocyphellaria granulata (Church. Bab.) Malme

See Galloway (1985) for a full description and p.35, couplet 16, for diagnostic features. The species is the asexual counterpart of P. faveolata and is recognised by the presence of coarse, marginal and laminal granular soredia. However, the upper surface is more shallowly faveolate in P. granulata and, in Tasmanian specimens, the lower surface is usually pale brownish. The chemistry of the two species is identical [physciosporin etc., Code B of Wilkins & James (1979)]. P. granulata has a very restricted distribution in Tasmania and is known only from the northern and eastern escarpment of the Central Plateau. There it occurs mostly on rocks in wet sclerophyll forest, associated with P. delisea, Parmelia signifera and Lobaria scrobiculata. It is also an occasional epiphyte at the margins of rainforest or in wet gullies. The species is also known from New Zealand and southern South America.

153. Pseudocyphellaria cf. insculpta (Stiz.) D. Galloway

Thallus small, thin and fragile, ± orbicular to spreading, loosely to closely attached, mostly to c. 4 cm diam., frequently with green leaflets of P. subvariabilis attached. Lobes branched, entangled, to 5 mm wide, flat or concave, ± elongated, finely divided and incised, often ± lobulate, phyllidiate at the margins. Upper surface greyish blue-green when wet, dull grey to grey-brown when dry, smooth to undulate or weakly faveolate, often ± maculate, sometimes with white tufts of silky tomentum when very young. Medulla white. Photobiont blue-green. Lower surface cream to brown, shaggy tomentose to the margins. Pseudocyphellae white, minute, most conspicuous along the lobe margins. Apothecia unknown.

This species is the blue-green photosymbiodeme of P. subvariabilis. It is common (but easily overlooked) in rainforest as small thalli bearing green leaflets of the latter species. Such individuals typically occur in the wettest, most shaded habitats on logs or low twigs. Larger, "free-living" thalli are rare and usually found only in habitats where P. subvariabilis is poorly developed, e.g. on trunks in young or high altitude forest. Like P. subvariabilis, P. cf. insculpta is very variable, with either entire or dissected, phyllidiate lobe margins. The upper surface may be evenly coloured or pockmarked with maculae. Scattered tufts of silky

tomentum may be present on the upper surface of very young thalli. P. cf. insculpta is also known from Australia.

154. Pseudocyphellaria intricata (Delise) Vainio

See Galloway (1985) for a full description and p.34, couplet 12, for diagnostic characters. The species is very rare and known only from the margins of rainforest. In young plants, the punctiform soralia on the upper surface may resemble pseudocyphellae. P. intricta is cosmopolitan.

155. Pseudocyphellaria rubella (J.D. Hook. & Taylor)D. Galloway & P. James.

See Galloway (1985) for a full description and p.34, couplet 8, for diagnostic characters. P. rubella is recognised by its silky-tomentose upper surface and bright yellow granular soredia. It occurs in the rainforest canopy or in wet scrub or heath at the margins of rainforest. Commonly associated species include P. faveolata, P. billardieri, P. coronata and Nephroma australe. The reddish colour of the dry thallus (implied in the epithet "rubella") is generally developed or intensified after storage, and fresh, dry material is greyish to grey-pink. P. rubella is also known from New Zealand and Australia.

156. Pseudocyphellaria subvariabilis (Nyl.) Vainio

= P. multifida (Nyl.) D. Galloway & P. James

See Galloway (1985) for a full description and p.35, couplet 17, for diagnostic characters. The species is extremely common in Tasmania and ranges from wet forests to alpine heath. In most lowland rainforest communities, it is associated with Psoroma microphyllizans and is the dominant and most conspicuous epiphyte in shaded, basal habitats. It occurs on smooth-barked trunks, low twigs and mossy logs but with increasing altitude, it becomes more restricted to rocks, logs or peaty soil. The species exhibits a very wide range of variation, even within a single population. In deep shade, the lobes are usually very thin, narrow and crowded. In more exposed habitats such as mossy dead trees in clearings, the lobes may be leathery, broad, less divided and ± olive-brown. The tomentum may be short and felt-like or long and shaggy. The species is the green photosymbiodeme of P. cf. insculpta (see above) and young thalli in

the wettest, shadiest habitats may be attached to this species at the base. P. subvariabilis is known from Australia and New Zealand and is considered palaeotropical by Galloway (1985). The record of P. dissimulata from Tasmania (Shirley 1893) refers to P. subvariabilis.

157. Pseudopyrenula galactina Shirley

Thallus crustose, thin to rather thick, deeply cracked, greyish white, pale yellowish or olive-grey, forming spreading patches to 10 cm across, not delimited at the margins. Perithecia numerous, immersed, obscured by cortex, occasionally ± sub-emergent, becoming eroded, excavate and forming blackish pits to c. 0.3 mm diam. Ostiole central, minute, puncate, blackish, often with a grey rim. Paraphyses simple to sparingly branched, free. Spores hyaline to grey, becoming brownish, ellipsoid, 14-22(-26) x 5-10 µm, 4-locular, not constricted at the septa, arranged in the ascus obliquely in a single row. Locules lenticellular, rhomboid or hexagonal.
Chemistry: thallus K+ orange-brown (sometimes weak), KC-, Pd-, C-, UV+ faint orange

Shirley (1894) stipulates hyaline spores for this species but an examination of his type specimen (BRI 351370) revealed some brownish spores, suggesting the species is actually a Pyrenula. Additional specimens collected during the present study contain abundant brown spores but are similar to the type in morphology, chemistry and in the dimensions of the spores and their arrangement in the ascus. Fertile perithecia are very inconspicuous and are evident as superficial, ± hemispherical "bumps" with a central pore. Sometimes the thalline veil is very thin and the perithecia are almost emergent. However, the species is always abundantly pockmarked with old excavate perithecia.

P. galactina is widespread on mature, rough-barked trunks in low-level, shaded rainforest habitats and is particularly well-developed on dry flakes of decorticating Nothofagus cunninghamii bark. The species is still poorly known and requires further collection and study.

158. Psilolechia lucida (Ach.) Choisy

Thallus leprose, pale yellow-green to lemon yellow. Apothecia bright lemon yellow, immarginate, < 0.25 mm diam. Hymenium interspersed with yellow granules which dissolve in K. Spores hyaline, ellipsoid to clavate, 5-7.5 x 2-3 µm.
Chemistry: rhizocarpic acid

The species is common and widespread in very dry, microhabitats on wood, soil or on roots exposed by erosion. Typical habitats include underhangs in road cuttings or along stream banks. Tasmanian specimens are usually abundantly fertile. The species is a new record for Tasmania and is widespread in the Northern Hemisphere [see also Duncan (1970) under Lecidea lucida].

159. Psoroma asperellum Nyl.
= Pannaria imbricata Nyl.

Thallus squamulose. Squamules discrete and ± dispersed, or imbricate, often on a thin black prothallus, flat or ascending, rounded, crenate, incised or lobulate, mostly < 1 mm across, bright green when wet, pale greyish green when dry. Cephalodia usually abundant, pale blue-grey when wet, inconspicuous when dry, convex or flat and ± squamule-like. Apothecia 0.5-1.5 mm diam. Disc pale orange-pink to orange-brown, plane to convex. Thalline margin crenulate, occasionally ± squamulose. Spores simple, hyaline, ellipsoid, 17-23 x 7-10 µm, with a minutely roughened, warted epispore.

P. asperellum is extremely common and widespread in Tasmanian rainforest on rough bark or over bryophytes. It occurs in shaded habitats and is often associated with Parmeliella nigrocincta and Sphaerophorus spp. The species is particularly variable when muscicolous or on twigs and is clearly related to Psoroma sp.2 (see below). P. asperellum also occurs in New Zealand and South Africa. Further data on the species are given by Galloway (1985)(see also p.50, couplet 103).

160. Psoroma durietzii P. James & Henssen

See James and Henssen (1975) for a full description and discussion of this species and p.54, couplet 127, for diagnostic characters. The species is recognised chiefly by its blue-grey, sorediate cephalodia. The lobes may be laterally contiguous and crowded, or discrete and well-separated. A dense, byssoid, black prothallus is often present [contrary to the key to the genus in Galloway (1985)]. Fertile material is rare but the apothecial disc is usually gyrose-etched and with thalline inclusions or a central thalline "plug". Chemistry includes pannarin (thallus Pd+ bright orange-red).

P. durietzii is widespread and common in Tasmania. It is mostly found in rainforest or subalpine woodland on rough or smooth bark (or rarely on rocks). It occurs in well-lit habitats, in the canopy, in clearings or at the forest edge. The species is also known from New Zealand.

161. Psoroma euphyllum Nyl.

See Galloway (1985) for a full description and p.54, couplet 126, for diagnostic features. The ± free, centrally attached, deeply incised lobes are unique amongst Tasmanian representatives of the genus. The thallus reacts Pd+ orange-red (indicating pannarin).

P. euphyllum is uncommon in Tasmania and occurs on twigs of subdominant trees in closed rainforest or on low undershrubs in forests with broken canopies. It is locally common in mature "mixed forests" in the Arthur River catchment, north-western Tasmania, and is often associated with Pseudocyphellaria coronata and Nephroma australe. The species is closely related to Psoroma calophyllum from South America and is also known from New Zealand.

162. Psoroma leprolomum (Nyl.) Räsänen

= P. sphinctrinum var. leprolomum Nyl.

Thallus foliose, rosette-forming, to c. 8 cm diam., pale glaucous green when wet, ± unchanged or pale yellow-grey to yellow-brown when dry. Prothallus black, variable, scarcely evident, or prominent and byssoid. Lobes laciniate, c. 2-5 mm wide, shallowly faveolate to undulate, mostly concave, with raised margins, lobulate, sorediate, with apices ± rounded and ± minutely tomentose. Soredia granular, pale glaucous grey, mainly marginal, occasionally laminal

and congesting the centre of the thallus. Cephalodia inconspicuous, uncommon, small, globose, purplish brown. Apothecia not seen.
Chemistry: pannarin and unknown substances (thallus Pd+ bright orange-red)

This species is clearly similar to P. leprolomum sensu Galloway (1985) although that author makes no mention of the chemistry of New Zealand specimens. The Tasmanian species is also similar to some forms of P. microphyllizans in which the lobe margins are eroded. In cases of doubt, the Pd+ reaction of P. leprolomum is diagnostic (see also p.54, couplets 128-129). P. leprolomum is uncommon but widespread in Tasmania and is mostly found in high altitude vegetation on smooth bark or amongst mosses. The species has also been recorded from Australia, New Zealand and South America but it is not clear whether all these records refer to the same taxon.

163. Psoroma microphyllizans (Nyl.) D. Galloway
= P. sphinctrinum var. microphyllizans Nyl.

Thallus foliose, rosette-forming, to c. 10 cm diam., bright green when wet, pale greyish green when dry, turning dull olive-green to cinnamon brown with storage, occasionally with a black, ± fibrous prothallus evident at the margins or between the lobes. Lobes laciniate, ± elongate and radiating, 1-2 mm wide, very closely adnate throughout, laterally contiguous, crowded and imbricate in the centre of the thallus, ± discrete at the periphery, with apices thickened on the underside. Margins lobulate, with dense, ± globose to flattened phyllidia, often becoming eroded and resembling coarse soredia. Upper surface smooth, neither scabrid nor tomentose. Cephalodia abundant, mostly wrinkled, globose to flattened. Apothecia abundant, to 3.5 mm diam., mostly roundish. Disc pale orange-pink to orange-brown, plane to undulate, smooth or occasionally gyrose-etched, cracked or with a central depression. Thalline margin crenulate, radially striate, occasionally phyllidiate. Spores hyaline, ellipsoid, 14-22 x 7.5-12 µm, with a distinct epispore, smooth or only minutely uneven.
Chemistry: thallus Pd-, K-, KC-, C-

P. microphyllizans is an extremely common and widespread species, occurring in virtually all rainforest communities as well as in most wet sclerophyll forests. It is usually one of the dominant macrolichens in shaded habitats, occurring on smooth bark or on

bryophytes over bark, wood or rocks. Commonly associated species include Pseudocyphellaria subvariabilis, P. delisea and Sphaerophorus tener. Higher up on tree trunks or in more open forests, it associates with Pseudocyphellaria billardieri. In high altitude forests, P. microphyllizans may have very eroded lobe margins which appear sorediate. However, thallus colour and the negative Pd reaction serve to distinguish it from P. leprolomum. P. microphyllizans is known also from Australia and New Zealand (see Galloway 1985).

164. Psoroma paleaceum (Fr.) Nyl.

See Jørgensen (1978) for a complete description (under P. hypnorum var. paleaceum) and p.49, couplet 99, for diagnostic features. The Tasmanian species has small spores, (14.5-)16-20 x 9.5-13 µm, and its hymenium is I-. Thus it differs from the European species which has larger spores, 22-34x9-12 µm, and an I+ blue hymenium (Jørgensen op.cit.). The species is uncommon in Tasmania and is found mostly in high altitude rainforest on wet, mossy trunks and logs. Jørgensen (op. cit.) records P. paleaceum from Europe, southern South America, Tristan da Cunha and New Zealand but warns that the Southern Hemisphere taxon may not be conspecific with the European one.

165. Psoroma pholidotoides (Nyl.) Trevisan

= P. reticulatum (Hue) Zahlbr.

See Galloway (1985) for a complete description and p.50, couplet 101, for diagnostic features. P.pholidotoides has distinctive, broadly ellipsoid spores with a thick, smooth epispore and broadly acuminate to rounded apiculae at the ends, 18-29 x 12-15 µm (12-19.5 x 8.5-12 µm excluding epispore). The chemistry of the species is complex but usually includes usnic acid, often only in trace amounts. High concentrations of usnic acid appear to be most prevalent in specimens from exposed habitats.

P. pholiodotoides is common and widespread in wet forest and scrub, ranging from lowland to subalpine altitudes. It is mostly found on smooth bark on the upper parts of tree trunks, on the main branches of the canopy or in forest clearings. It may also occur on rocks. The species is also known from New Zealand.

An additional yellow-green species of Psoroma, similar to P. pholidotoides, is known from several, widely-scattered, mainly high altitude localities. In this species, the squamules are adnate but mostly ± dispersed and discrete. The apothecial disc commonly has a central, thalline, squamule-like plug, and the spores are subglobose, 8.5-12 µm diam., with a prominently warted epispore to c. 2 um thick. This species occurs in habitats similar to P. pholiodotoides but requires additional collection and study to be adequately circumscribed.

166. Psoroma soccatum R. Br.

See Galloway (1985) for full description and p.49, couplet 95, for diagnostic characters. The spores of P. soccatum are identical to those of P. pholidotoides. The species occurs in similar habitats to P. pholidotoides and is often associated with Pseudocyphellaria rubella, P. faveolata, P. billardieri and P. coronata. It is also known from New Zealand and Australia.

167. Psoroma sp.1

Thallus squamulose, irregularly spreading to c.10 cm diam., dull green when wet, dull olivaceous green-grey when dry. Squamules mostly c.0.5 mm across, thin, flat, minutely lobulate, microphylline, imbricate in the centre of the thallus and coalescing to form an adnate crust. Prothallus poorly developed, thin, patchy, film-like, greyish to black. Cephalodia abundant, ± flattened, plicate, brownish, c. 1 mm diam. Apothecia to 2 mm diam., ± regularly scattered, roundish. Disc deep orange-brown, plane to convex, smooth, without etchings or sterile, thalline inclusions. Margin thin, crenulate, not or scarcely inrolled. Spores ellipsoid, 15.5-21 x 7-12 µm, with a thin, distinctly warted, roughened epispore.
Chemistry: no substances detected

This species is similar to P. pholidotoides and its distinguishing characteristics are summarised on p.50, couplet 101. The two species also differ in the appearance of their apothecia which in P. pholidotoides are often crowded, irregularly shaped due to mutual pressure, and with the disc red-brown to dark brown, flat to concave. Psoroma sp.1 is known in Tasmania from three widely separated rainforest localities. It occurs in deep shade on rotting

wood or smooth bark on trunks and twigs, and is commonly associated with P. microphyllizans and Pseudocyphellaria subvariabilis.

168. Psoroma sp.2

Thallus squamulose. Squamules discrete, ascending to ± perpendicular to the substrate, narrow elongate, ± dichotomously branched, to 0.5 mm wide, with crenulate margins and apices, crowded and mostly forming a fruticose cushion to c. 5 mm tall. Prothallus black, thin, patchy, often absent. Upper surface bright green when wet, pale grey-green when dry, turning ± olivaceous grey in storage. Lower surface whitish fawn, ecorticate. Cephalodia abundant, dark blue-grey, squamulose, inconspicuous when dry. Apothecia 2-3 mm diam., nestling amongst the squamules. Disc orange-pink to orange-brown, plane to convex. Thalline margin thin, crenulate, occasionally squamulose, often ± excluded in very convex fruits. Spores ellipsoid, 19-20 x 8-10 µm, ± smooth to minutely warted.
Chemistry: no substances detected

This species is clearly related to P. asperellum and may yet prove to be merely an extreme form of that species. Despite the abundance of apothecia in the specimens examined, few mature spores could be located. Both species are alike in the colour of the thallus and apothecial disc but Psoroma sp.2 differs in its larger apothecia and distinctive, caespitose growth habit. Psoroma sp.2 is uncommon but widespread in Tasmania and occurs mostly in deep shade on rotting wood or bark in thamnic and implicate rainforests.

169. Psoroma sp.3

Thallus squamulose. Squamules ± discrete and dispersed, c. 1-2 mm wide, ascending, markedly concave when dry, ± rounded, crenate or irregularly incised. Prothallus black, absent or well-developed. Upper surface pale glaucous green when wet or dry, often minutely frosted-tomentose at the margins of the squamules. Lower surface white, ecorticate, arachnoid. Apothecia to 2 mm diam, with thin, crenulate thalline margin. Disc plane, red-brown to blackish, ± greyish pruinose when young. Spores ellipsoid, (9.5-)12-20 x 7-10 µm, with smooth epispore.
Chemistry: pannarin and unknown substances (medulla Pd+ bright orange-red)

This very distinctive species is common and widespread in Tasmania, particularly in thamnic and implicate rainforest from sea-level to subalpine altitudes. It occurs in shade directly on smooth bark or over epiphytic bryophytes on such hosts as Eucryphia milliganii, Anodopetalum and Orites diversifolia. The species is also common in tall, wet scrub on the thick, papery bark of Melaleuca squarrosa or Leptospermum lanigerum where it may be associated with Wawea fruticulosa.

170. Psoroma sp.4

Thallus foliose, rosette-forming, to c. 10 cm diam., pale glaucous green when wet or dry (even after storage), often with a ± yellowish tinge, ± loosely attached by bushy, brown to grey-black rhizines which occasionally protrude beyond the lobe apices. Upper surface minutely scabrid, ± mealy and often faintly reticulately cracked. Lobes 1-2 mm wide, rather short, irregularly branched, imbricate and congested throughout. Margins densely lobulate-phyllidiate but not abraded, phyllidia mostly decumbent. Cephalodia occasional, convex, wrinkled. Apothecia to 2 mm diam. Disc pale orange-brown to brown, plane to undulate, occasionally gyrose-etched. Thalline margin thick, ± inrolled, crenate, radially striate. Spores hyaline, ellipsoid, 13-22 x 7.5-13 µm, with a thick, warted epispore. Chemistry: thallus Pd-, K-, C-, KC± orange-brown

Psoroma sp.4 is locally common at the margins of rainforest or in the understorey of open wet sclerophyll forests where it occurs on Acacia, Bedfordia, Cassinia, Olearia and Helichrysum. The species is rather similar to P. leprolomum from which it differs by its narrower lobes, absence of soredia, Pd- reaction and texture of the upper surface. It is also similar to P. microphyllizans from which it differs by such additional features as thallus colour, shorter, irregular, non-radiating, thicker lobes and non-eroded lobe margins (see p.54, couplet 129). Moreover, dense bushy rhizines never protrude beyond the lobe apices of P. microphyllizans which, in general, is more closely attached to its substate. Although both species can co-occur at the margins of rainforest, Psoroma sp.4 is not known from within rainforest.

An additional, rare species of Psoroma has a similar pale colour and dense, marginal phyllidia. This species has a smooth upper

surface, a well-developed prothallus which may extend to 3 mm beyond the periphery of the thallus as well as protruding between the lobes, and broadly ellipsoid to subglobular, distinctly warted spores, 10–13.5 x 7–11.5 µm. This species is known from several small rainforest collections but requires further collection and study to be adequately circumscribed.

171. Psoromidium aleuroides (Stirton) D. Galloway
= Psoromaria descendens (Nyl.) Nyl.

See Galloway and James (1985) for a full description and p.49, couplet 98, for diagnostic characters. The species is widespread in Tasmania and occurs on smooth bark or rocks in wet forest, scrub and heath. It is usually found in moderate shade and is commonly associated with Parmeliella nigrocincta, Pseudocyphellaria billardieri and Psoroma spp. The species is also known from New Zealand and Australia.

172. Psoromidium versicolor (J.D. Hook. & Taylor) D. Galloway

See Galloway and James (1985) for a full description and p.49, couplet 98, for diagnostic characters. The species is uncommon in Tasmania and is known only from rainforest where it occurs on smooth bark on low twigs or on understorey shrubs. P. versicolor is also known from southern South America and the Auckland Islands.

173. Pyrenula sp.

Thallus crustose, thin, very variable, pale greyish, fawn or dull olive, not delimited at the margins. Perithecia emergent, distinctly carbonised, black, hemispherical to ± conical, c. 0.7 mm wide, becoming eroded and forming blackish pits. Ostiole central, minute, sometimes ± pointed. Paraphyses simple, free. Spores oblong-ellipsoid, grey or hyaline when young, brown when mature, 19-26.5 x 7-10 µm, 4-locular, often ± constricted at the septa and uneven in outline, locules mostly angular, ± hexagonal.
Chemistry: thallus K+ yellow→brownish, KC-, C-, Pd-, UV± pale creamy grey

This taxon is common on trees with smooth bark, particularly Atherosperma. It occurs in low, shaded habitats, associated with Arthothelium spp., Thelotrema lepadinum, Bacidia weymouthii and other crustose lichens.

The pyrenocarpous lichens as a group have been largely neglected during this project and require considerably more collection and study. In addition to this entity and Pseudopyrenula galactina, at least two species of Arthopyrenia were collected but have not been included in this account. Also, Shirley (1894) described Pyrenula chloroplaca from rainforest vegetation on Mt. Wellington. This species is distinguished by its yellowish cream, UV+ orange thallus and its 4-locular spores, 14-22 x 8-12 µm, in which the apical locules are very small. It was not found during the present study.

174. Ramalodium sp.

Thallus fruticose, homoiomerous, olive-black. Lobes knob-like, irregularly shaped, 0.5-1 mm tall x 0.2-0.4 mm wide when dry, swelling noticeably when wet, simple or branched occasionally, erect, ascending or (rarely) prostrate, dispersed irregularly over a thin, blackish film. Photobiont Nostoc. Apothecia dark red-brown to blackened, to 1 mm diam., plane to convex, with a thin, barely perceptible proper margin. Proper margin (in section) cupular, closed below, to c. 250 µm thick. Hymenium c. 50 µm thick, I+ blue. Hypothecium c. 50 µm thick. Spores simple, hyaline, globose, 7-10 µm diam., uniseriate in the ascus, with wall ± uneven, c. 1.5 µm thick.

This species is not mentioned by Henssen (1979) and appears to be new. It is known from a single collection from implicate rainforest near the Frankland River, north-western Tasmania. The species was associated with Wawea fruticulosa and occurred on the spongy bark of Melaleuca squarrosa in deep shade.

175. Ramonia muscicola A. Vězda ined.

Thallus crustose, thin and patchy, dull greenish grey. Apothecia pale grey-white, often crowded, to 0.5 mm diam., ± hemispherical, constricted at the base. Thalline margin inrolled at first, ± obscuring the disc except for a central, roundish gap, becoming scabrid, radially cracked, exfoliating. Disc pale grey-brown to black, concave. Paraphyses to 2 µm thick, unbranched, septate, with slightly enlarged apices. Spores hyaline to pale greyish, ellipsoid, oblong to ± clavate, 1/ascus, muriform, thin-walled, 108-272 x 28-42(-60) µm, number of cells ∞, septa thin.
Chemistry: thallus and margins of apothecia Pd-, K-, C-, KC-

R. muscicola is widespread across northern and north-western Tasmania in rainforest and some sclerophyllous communities. It is locally common in callidendrous rainforest above c. 600 m in the northern foothills of the Central Plateau. The species occurs over bryophytes on rough or smooth bark in deep shade and is commonly associated with Sphaerophorus tener, Psoroma microphyllizans and Pseudocyphellaria delisea. Ramonia muscicola is also known from New Zealand.

176. Rinodina dissa (Stirton) Mayrhofer
= Buellia dissa (Stirton) Zahlbr.

See Mayrhofer (1984) for a complete description. R. dissa is recognised by its thin, whitish, crustose thallus, black lecideine apothecia and brown, bilocular spores, 24-32 x 11-15 µm. Apart from the type collection (Hugh Paton 1875, sine loco), the species is known in Tasmania from a single collection from rainforest at Little Fisher River, northern Tasmania. It occurred on well-lit, smooth Nothofagus cunninghamii branches, associated with Parmelia testacea, P. tenuirima, Menegazzia weindorferi and Pertusaria nothofagi. This Tasmanian specimen was identified by Dr. H. Mayrhofer. R. dissa is also known from Australia.

177. Roccellinastrum neglectum Henssen & Vobis

See Henssen et al. (1983) for a complete description and p.36, couplet 22, for diagnostic features. The species is extremely rare in Tasmania and is known from only two localities in implicate rainforest in western Tasmania. It occurs on smooth, moist trunks in shade at low levels in the forest and is associated with Sphaerophorus melanocarpus and Pseudocyphellaria subvariabilis. Thus its habitat ecology is distinct from that of the superficially similar species, Sagenidium molle, which occurs on very dry, rough bark. Roccellinastrum neglectum is also known from New Zealand.

178. Sagenidium molle Stirton

See Galloway (1985) for a complete description and p.36, couplet 22, for diagnostic features. The genus is discussed by Henssen et al. (1979). S. molle is widespread and common in Tasmanian rainforest where it occurs on very dry, fissured trunks of mature trees. It ranges from near the ground to high on the upper trunk and

may also extend onto the undersides of large branches. Individual thalli can attain sizes of up to 60 cm across. Associated lichens include Lecanactis abietina, Lepraria incana and species of Caliciales. Sagenidium molle also occurs in New Zealand.

179. Schismatomma sp.

Thallus leprose, ecorticate, pale yellow, with margins ± pale greyish, byssoid. Apothecia immarginate, strongly convex, to 0.8 mm diam., pale greyish to pale yellow, ± pruinose when young. Epithecium with yellow-brown granules dissolving in K. Hymenium c.70 µm thick, colourless. Hypothecium pale brown to colourless, K-. Paraphyses anastamosing. Spores hyaline, filiform, sigmoid, with rounded ends, indistinctly multiseptate, 36-60 x 1-2 µm.
Chemistry: thallus Pd ± pale yellow-orange (weak), K+ yellow-orange, KC+ orange, C-, UV+ bright purple in streaks and at the margins

Schismatomma sp. is rare and known from two rainforest localities in north-western Tasmania where it occurs on smooth, young trunks of Nothofagus cunninghamii. Only one species of the genus, S. congerens (Nyl.) Zahlbr., has been previously reported from Tasmania but the holotype of this species corresponds to a Lecanactis (P. James pers. comm.).

180. Scoliciosporum cf. pruinosum (P. James) Vězda

Thallus ± granular, ecorticate, whitish grey. Photobiont cells rounded, 8-10 µm diam. Apothecia to 0.5 mm diam., immarginate, convex to ± subglobose, whitish to very pale pink, ± translucent when wet. Epithecium with yellow-brown granules dissolving in K. Hymenium and hypothecium colourless. Paraphyses anastamosing. Spores hyaline, filiform, sigmoid, 24-34 x 1-2 µm.
Chemistry: thallus K-, C-, Pd-, KC+ pink, UV+ white

This species is known from a single collection from rainforest at Little Fisher River. It occurred in a rain-sheltered microhabitat (beneath a large limb) on a young, smooth, shaded trunk of Nothofagus cunninghamii. The Tasmanian taxon is clearly similar to the European species, Scoliciosporum pruinosum s. str. (see James 1971), which differs chiefly in its chemistry (no substances reported).

181. Siphula cf. dissoluta Nyl.

Thallus very pale whitish grey throughout, sometimes with a ± bluish tinge, forming compacted, shrubby tufts. Lobes to 5 mm wide, lacerate, branched, convolute, fenestrate, ± thickened at the apices and margins, often with thickened midribs evident on the underside. Surface scabrid, mealy, particularly on the underside. Apothecia unknown.

Chemistry: thamnolic acid, trace decarboxythamnolic acid (medulla K+ yellow, occasionally darkening to purplish)(analysis by Dr. J.A. Elix)

Siphula cf. dissoluta is locally common in implicate rainforest in western Tasmania where it occurs on very wet, mossy trunks and low branches. Athrotaxis selaginoides is a particularly favoured substrate. Associated lichens commonly include Sphaerophorus scrobiculatus, S. melanocarpus and Siphula sp. The New Zealand species, S. dissoluta s. str., differs from the Tasmanian taxon in its chemistry which comprises hypothamnolic acid (medulla UV+ blue-white) [see Galloway 1985]. Further work is required to ascertain the status of the Tasmanian species which may yet prove to be only an extreme form of S. decumbens.

182. Siphula sp.

Thallus chalky white, forming subpendulous tiers. Lobes 0.5-1.2 mm wide, elongate, strap-shaped to (rarely) subterete, smooth to scabrid-mealy.

Chemistry: thamnolic acid (medulla K+ yellow)

The species is rare and known only from rainforests in western Tasmania. It occurs on mossy trunks, particularly Athrotaxis selaginoides, and is often associated with Siphula cf. dissoluta. Siphula sp. may be equivalent to S. ramalinoides from New Zealand (see Galloway 1985) but a comparison with authenticated material is required.

183. Sphaerophorus insignis Laurer

See Galloway (1985) for a full description and p.42, couplet 55, for diagnostic features. The species is recognised by its flattened branches, veiled mazaedium, large brown spores and by the presence of protocetraric acid. Although Galloway (op. cit.)

describes the fertile branches as up to 2.6 mm wide, some particularly robust Tasmanian specimens are c. 5 mm wide. It is generally the most common rainforest species of the genus and occurs in moist, shaded habitats, typically on trunks with rough bark. Outside rainforest, it is known from peaty soil in rock crevices in alpine or subalpine heath. S. insignis is known also from Australia, New Zealand and southern South America.

184. Sphaerophorus ligulatus G. Kantvilas ined.

Thallus corticolous, markedly flattened. Fertile branches to c. 2 cm tall and 1-4 mm wide, simple or only sparingly branched, tongue-like, with apices rounded, occasionally deflexed and forming a slight hood around the mazaedium, margins entire, smooth. Sterile branches few, scattered, shorter than fertile branches, sparingly branched mainly at the base. Upper surface greyish green to olivaceous yellow-green, rarely blackened, sparingly transversely cracked, smooth throughout or wrinkled only above the apothecia. Lower surface whitish, smooth to markedly wrinkled on the largest branches. Apothecium ventral, ± as wide as supporting branch or only slightly enlarged. Mazaedium exposed from earliest stages, black, powdery, convex, not globose. Spores brown, spherical, surrounded by black carbonaceous material, 6-8 µm diam.
Chemistry: protocetraric acid, sphaerophorin (sometimes in trace amounts only), ± unknown UV+ orange

The species is widespread but uncommon in a range of rainforest vegetation in Tasmania and occurs in shade on moist, rough bark in association with S. insignis, S. melanocarpus, S. murrayi and S. tener. The small brown spores of S. ligulatus are unique amongst Tasmanian representatives of the genus. The ± curved, tongue-like, mainly simple fertile branches are also distinctive although some forms of S. patagonicus are similar. However, S. patagonicus has large spores and lacks protocetraric acid (see also p.42, couplet 54). On the basis of the work of Ohlsson (1974), S. ligulatus is most similar to S. imshaugii, at least in spore size and major chemical constituents. However, until authentic material of S. imshaugii can be studied, the Tasmanian taxon is provisionally regarded as new.

185. Sphaerophorus macrocarpus Ohlsson in D. Galloway

See Galloway (1985) for a full description and p.43, couplet 57, for diagnostic features. The species is very polymorphic but is recognised by its ± hemispherical apothecia, supported on terete fertile branches which often arise in pairs or three's from the apices of broadly flattened sterile branches. The sterile branches may be up to 12 mm wide, thin and resemble those of S. scrobiculatus. Chemical constituents include sphaerophorin, ± stictic acid. The species is uncommon in Tasmania and occurs in habitats similar to S. insignis. It is mostly encountered in thamnic rainforest and can be locally abundant in some high altitude communities. S. macrocarpus is also known from New Zealand.

186. Sphaerophorus melanocarpus (Sw.) DC.

= Sphaerophoron australe Laurer

See Galloway (1985) for a full description and p.43, couplet 58, for diagnostic features. The species is widespread and common in Tasmanian rainforest in habitats similar to S. insignis. However, it appears to be marginally more shade-tolerant and predominates in the shadiest, moistest habitats. S. melanocarpus is very polymorphic and is also abundant on peaty soil in rock crevices in high altitude heaths. Specimens from peat typically consist of crowded, ± terete sterile branches and the apothecia may be orientated ± apically rather than laterally. In all habitats, the species has a distinctive pale bluish green-grey colour and all specimens examined contained sphaerophorin and stictic acid. S. melanocarpus is cosmopolitan.

187. Sphaerophorus murrayi Ohlsson in Tibell

See Galloway (1985) for a full description and p.42, couplet 55, for diagnostic features. The species is rare in Tasmania and known from two localities in thamnic rainforest in the South-West. In one specimen, the margins are ragged, with small branchlets and outgrowths, whereas in the other the margins are entire. S. murrayi differs from S. patagonicus in the presence of protocetraric acid. It differs from S. insignis in the presence of an exposed (rather than veiled) mazaedium. The species co-occurs with S. insignis and S. melanocarpus on rough mossy trunks in deep shade. S. murrayi is also known from New Zealand, Hawaii, New Guinea and Indonesia.

188. Sphaerophorus patagonicus (Dodge) Ohlsson in D. Galloway

See Galloway (1985) for a full description and p.43, couplet 56, for diagnostic features. The species is rare and found mostly in high altitude callidendrous forests across northern Tasmania. It occurs on shaded, moist, mossy trunks with rough bark (usually Nothofagus) and is commonly associated with S. insignis. S. patagonicus is more variable in Tasmania than suggested by the accounts of Ohlsson (1974) and Galloway (1985). Its lobe margins may be entire and smooth or ragged and with short lateral outgrowths and branchlets. The species is similar to S. murrayi and can only be reliably distinguished from this taxon by the absence of protocetraric acid. S. patagonicus is known also from New Zealand and southern South America.

189. Sphaerophorus ramulifer Lamb

See Galloway (1985) for a full description and pp. 41 and 43, couplets 48 and 58, for diagnostic features. The species is recognised mainly by its yellow colour, due to the presence of isousnic acid, and small grey spores, 8-10 µm diam. The only other yellowish species in the genus, S. notatus (see Tibell 1985), has large brown spores, 12-16 µm diam., and has not been recorded from Tasmania. S. ramulifer is common and widespread in Tasmanian rainforest. It occurs in more exposed habitats than S. insignis and is particularly abundant in high altitude forests, associated with S. tener. The species is also known from New Zealand, Australia and southern South America.

190. Sphaerophorus scrobiculatus (Church. Bab.) Sato

See Galloway (1985) for a full description and p.43, couplet 56, for diagnostic features. S. scrobiculatus is chemically unique, lacking sphaerophorin and contains unknown compounds. The main "scrobiculatus" unknown appears as a pale yellow spot in standard, charred t.l.c. analyses. In Tasmania, the species is virtually confined to implicate rainforests where it occurs on moist limbs and trunks, commonly associated with S. melanocarpus, Siphula spp. and leafy hepatics. When well-developed, it is easily recognised by its broad, flattened branches and conical, flaring receptacle with a coarsely scrobiculate upper surface. However, some depauperate forms may resemble S. macrocarpus, although this species is chemically

different, has ± hemispherical apothecia and is rare in implicate rainforest. S. scrobiculatus also occurs in New Zealand and southern South America.

191. Sphaerophorus tener Laurer

See Galloway (1985) for a full description and p.41, couplet 48, for diagnostic features. S. tener is extremely common and widespread in Tasmania and is found in rainforest, wet scrub, heath and alpine vegetation. In rainforest, it is primarily an epiphyte on trunks and twigs, and ranges from the forest floor to the canopy. Outside rainforest, it also occurs on peaty soil or rocks. The species is locally abundant on Precambrian quartzite and mudstone outcrops in sedgeland-heath in south-western Tasmania. In this habitat, it is extremely polymorphic and is usually associated with Umbilicaria spp., Usnea torulosa and Parmelia signifera. Some extreme forms which are tufted or in which the lateral branches are eroded may have been previously mis-identified as Sphaerophorus fragilis or S. globosus. Although recorded in the 19th Century (see Wetmore 1963), neither of these species have been subsequently reported from Tasmania, either by Ohlsson (1974) or in recent surveys. S. tener is also known from Australia, New Zealand and southern South America.

192. Stereocaulon ramulosum (Sw.) Rauschel

= S. macrocarpioides Nyl.

= S. macrocarpum Rich.

= S. proximum Nyl.

See Galloway (1980b) for a full description and p.40, couplet 42, for diagnostic features. S. ramulosum is a common pioneer species of disturbed earth and stones. In rainforest, it occurs in open habitats along roadsides and riverbanks or on freshly exposed soil on the roots of windthrown trees. It is usually associated with species of Baeomyces and Placopsis. The species is very polymorphic and occurs throughout Tasmania in both high and low rainfall areas, ranging from sea-level to alpine altitudes. The only other common non-alpine Stereocaulon in Tasmania is the sorediate species, S. corticatulum. S. ramulosum is widespread in the Southern Hemisphere and is known also from the West Indies and Central America (Galloway 1980b).

193. Sticta fuliginosa (Dickson) Ach.

See Galloway (1985) for a full description and p.33, couplet 4, for diagnostic features. The species is rare in Tasmania and confined mainly to wet sclerophyll forests or to the scrubby margins of rainforest. Associated lichens include Collema leucocarpum, C. laeve, Leptogium azureum and species of Pannariaceae. Sticta fuliginosa is cosmopolitan.

194. Sticta limbata (Sm.) Ach.

See Galloway (1985) for a full description and p.33, couplet 5, for diagnostic features. The species is common at the scrubby margins of rainforest and in some wet heaths and sclerophyll forests. It is best developed on trees and shrubs of the Compositae (Olearia, Cassinia, Helichrysum) and is usually associated with Sticta sublimbata, Nephroma cellulosum and species of Collemataceae and Pannariaceae. Sticta limbata is cosmopolitan.

195. Sticta stipitata Knight

= S. shirleyana Müll. Arg.

Thallus foliose, ± palmately spreading, to 10 cm wide, thin, brittle when dry, attached by a short, ± terete stalk. Lobes variable, to 15 mm wide, usually deeply and complexly dissected, with ± rounded axils, margins entire, flat or ascending. Upper surface bright green when wet, pale grey-green when dry, occasionally ± suffused red-brown, smooth to shallowly wrinkled. Lower surface pale cream, fawn or brownish, rarely dark brown, sparsely pubescent, smooth or wrinkled and ribbed. Cyphellae prominent, crateriform, white, to 2 mm diam. but usually smaller. Photobiont green, internal cephalodia present. Apothecia lecideine, to 3.5 mm diam., scattered, mostly laminal. Disc pale orange-brown to dark brown, plane at first, becoming convex. Margin entire, very thin. Spores hyaline, 8/ascus, fusiform, (0-)1(-3) septate, (21-)24-36 x 6-8.5 µm.

S. stipitata is very common and widespread in many rainforest and wet sclerophyll communities. It occurs in moist, shaded habitats, typically amongst bryophytes at the base of tree trunks or on logs and rocks. Commonly associated lichens include Pseudocyphellaria subvariabilis, Psoroma microphyllizans, Collema subconveniens and Sphaerophorus spp. Very young plants in deep shade may be attached to small coralloid thalli of Dendriscocaulon dendriothamnodes at the

base. The relationship between these two lichens is discussed in detail by James and Henssen (1976). In rainforest, a continuum from virtually "pure" Dendriscocaulon with green leaflets of Sticta, to "pure" Sticta with a barely recognisable basal stalk of Dendriscocaulon has been observed. The physiological ecology of S. stipitata (as S. filix) is discussed by Rundel et. al. (1979).

S. stipitata is extremely variable, particularly when found in more exposed habitats such as on the upper parts of trees, at the forest margins or at alpine altitudes beneath shrubs or in rock crevices. In such habitats, the lobes are usually more divided, narrow, suffused brownish and the underside is darker brown and markedly wrinkled. When growing in a thick mat of bryophytes, the basal stalk may be almost absent and the thallus is secondarily loosely attached by parts of the underside. It remains to be seen if any of these forms constitute distinct taxa. Wilson (1893) reports 5-septate spores in this species. The species has previously been recorded in the literature on Tasmanian lichens as Sticta filix, a New Zealand endemic species. However, at present, S. stipitata is the only Sticta with a green photobiont known to me from Tasmania and early records of several other species, e.g. S. latifrons (see Wetmore 1963), may also be due to mis-identifications. The species also occurs in Australia.

196. Sticta sublimbata (Steiner) Swinscow & Krog

See Galloway (1985) for a full description and p.33, couplet 5, for diagnostic features. The species is locally common in wet heath and scrub at the margins of rainforest, from sea-level to alpine altitudes. Here it is mostly found on shrubs and trees of the Compositae and Myrtaceae, associated with S. limbata, Nephroma cellulosum, Collema spp. and Parmeliella nigrocincta. The species may also occur within rainforest, particularly in open montane communities dominated by Athrotaxis cupressoides. Sticta sublimbata also occurs in New Zealand.

197. Thelotrema decorticans Müll. Arg.

Thallus crustose, whitish, greenish grey or dull olive-grey, effuse, very thin, scurfy to almost absent. Apothecia 0.5-1 mm diam., with margins thick, cracked, exfoliating, pulverulent, ± obscuring the disc except for a central pore. Spores 8/ascus, muriform, fusiform-ellipsoid, sometimes slightly curved, 35-60 x 11-19 µm. Chemistry: thallus and margins of apothecia K-, Pd-, KC-, C-

See Galloway (1985) for further data. The species is morphologically indistinguishable from T. subdenticulatum (see below). T. decorticans is known from several localities, mostly in northern and north-western Tasmania, but may have been overlooked elsewhere. It appears to be rare in rainforest and is mostly encountered in marginal scrub or in "mixed" or wet sclerophyll forest. The species is a new record for Tasmania and is also known from New Zealand and Australia.

198. Thelotrema lepadinum (Ach.) Ach.

Thallus crustose, dull whitish grey. Apothecia immersed in ± hemispherical thalline warts, 0.5-1 mm diam., pierced by a central pore. Proper margin free, forming a thin veil ± obscuring the disc. Spores hyaline, to 8/ascus, muriform, with up to 12-14 transverse and 1-4 longtitudinal septa, 35-130 x 10-25 µm.

See Galloway (1985) and Bailey and James (1977) for further data. T. lepadinum is the most common Tasmanian species of the genus. It occurs in most rainforest communities as a pioneer species at low, shaded levels of the forest. With increasing age of the substrate, T. lepadinum is usually either shed on flakes of bark or is overgrown by bryophytes and macrolichens. However, it often persists on old dry trunks where it is associated with Lepraria incana. The species is very distinctive and is largely responsible for the pale greyish colour of many trunks and limbs in the forest. T. lepadinum is cosmopolitan.

199. Thelotrema subdenticulatum (Zahlbr.) G. Salisb.

See Salisbury (1972) for a full description. In gross morphology, the species is indistinguishable from T. decorticans and can be recognised only by its spores which are transversely 16-26 septate, 59-120 x 8-18 µm. Tasmanian specimens have been determined

by Dr. A. Vězda. The species is a new record for Tasmania and was previously known only from Juan Fernandez. It is widespread and common in Tasmanian rainforest and occurs either over bryophytes or directly on wood. The species is usually found in deep shade, associated with Sphaerophorus insignis, "Asteristion" lamelliferum and bryophytes. It is also common at the forest margins or in scrub on the fibrous bark of Eucalyptus nitida and species of Leptospermum and Melaleuca.

200. Usnea arida Mot.

See Galloway (1985) for a full description and p.41, couplet 47, for diagnostic features. In Tasmania, the species contains usnic and salazinic acids only, whereas New Zealand specimens also contain norstictic acid (Galloway op. cit.). U. arida is the most common rainforest Usnea and occurs in the canopy of virtually all communities. It is extremely polymorphic and, in rainforest, is typically bushy and subpendulous, with thin branches and abundant laterals. In more exposed habitats such as on emergent trees in heath, it is often sub-erect, inflated, with few or no laterals and coarse, thick main branches. U. arida is very similar to an undescribed species (no.204) and can be recognised with certainty only by its chemistry. Morphological separation of the two species is discussed under species no.204 (below). U. arida occurs also in Australia and New Zealand.

201. Usnea capillacea Mot.

See Galloway (1985) for a full description and p.40, couplet 45, for diagnostic features. U. capillacea is a common and widespread rainforest canopy species, particularly in western and south-western Tasmania. It is easily recognised by its very pale coloured, long, straggling, limp branches which form festoons on canopy branches and twigs. It is often particularly abundant on emergent, dead Nothofagus trees. U capillacea is known also in New Zealand.

202. Usnea molliuscula Stirton

See Galloway (1985) for a full description and p.40, couplet 46, for diagnostic features. The species is recognised by its abundant terminal apothecia, the absence of asexual propagules, its sparsely fibrillose main branches and the virtual absence of

secondary branches. Chemical constituents comprise usnic and salazinic acids. Although widespread, U. molliuscula is mostly found in high altitude callidendrous rainforest where it is a canopy twig species, associated with Pannoparmelia angustata, Lecidea laeta, Hypogymnia turgidula and Menegazzia retipora. It is also known from Australia and New Zealand.

Usnea molliuscula is related to U. scabrida and U. microcarpioides (=U. ramulosissima) and, in Tasmania, these species form an ecological and morphological continuum. U. molliuscula is lax, sparsely fibrillose and occurs mostly in rainforest. U. microcarpioides is subpendulous, abundantly fibrillose and occurs in marginally drier, more exposed habitats such as in wet sclerophyll forest. U. scabrida is an erect, densely tufted, very fibrillose species found in dry, exposed habitats such as in coastal heath, on solitary trees in pasture, on fenceposts and in dry sclerophyll forest. The three species may prove to be variants of a single, widespread polymorphic species.

203. Usnea rubicunda Stirton

= U. rubescens Stirton

See Galloway (1985) for a full description and p.40, couplet 44, for diagnostic features. Tasmanian specimens contain salazinic, norstictic and usnic acids. U. rubicunda is widespread but uncommon in Tasmania and occurs in rainforest, wet or dry sclerophyll forest and in coastal vegetation. The species is best developed in open wet sclerophyll forests in northern and north-eastern Tasmania. It is rare in rainforest and is found mostly on canopy twigs in north-western Tasmania. Usnea rubicunda is cosmopolitan.

204. Usnea sp.

Thallus fruticose, mostly subpendulous, to 12 cm long, yellow-green to pale greenish grey, much branched. Branches ± terete, to 2.5 mm thick, tapered gradually, not constricted at the axils, without fibrils, spinules or short, thin laterals, with numerous punctate pseudocyphellae, particularly towards the tips, becoming coarsely sorediate or (rarely) pseudoisidiate. Soralia to 0.5 mm diam. when well-developed, ulcerose, convex, with edges torn outwards. Apothecia not seen.

Chemistry: usnic acid, fumarprotocetraric acid + several unknown substances

The species is still poorly understood and, in the absence of chemical data, is difficult to distinguish from U. arida. U. arida tends to be very densely branched, with numerous short laterals and axillary constrictions and cracks. These are absent in Usnea sp. which tends to form a very loose tangle of evenly-tapered main branches. The coarse roundish soralia of Usnea sp. are distinctive but are often poorly developed and hence cannot be regarded as a reliable distinguishing character. Although most specimens of Usnea sp. tend to be greyish green rather than yellow (like U. arida), there is considerable overlap in colour between the two species. Any colour difference is probably linked to habitat ecology: Usnea sp. tends to occur in more shaded habitats than does U.arida and seems to contain lower concentrations of usnic acid (see also p.41, couplet 47).

Usnea sp. is locally abundant in high altitude callidendrous rainforest around the Central Plateau and in north-eastern Tasmania. It appears to be marginally more shade-tolerant than either U. arida or U. molliuscula and is commonly found in subcanopy habitats or on young limbs or trunks in clearings. Associated species include Parmelia testacea, P. tenuirima, Menegazzia weindorferi and Pertusaria nothofagi.

205. Wawea fruticulosa Henssen & Kantvilas

See Henssen & Kantvilas (1985) for a full description and discussion of this species and p.39, couplet 39, for diagnostic features. The species is common and widespread in the western half of Tasmania from sea-level to alpine altitudes, with a single outlying record from the north-eastern highlands. It is most commonly found as an epiphyte in wet scrub and low forests, especially on the papery bark of myrtaceous species, e.g. Melaleuca and Leptospermum. Wawea also occurs in some implicate rainforest communities either on myrtaceous trees or on Richea pandanifolia. In these habitats, it is mostly associated with bryophytes or grows in pure colonies. In subalpine forests, Wawea ocurs on the buttresses of Eucalyptus gunnii or E. subcrenulata and may be associated with species of Nephroma, Pseudocyphellaria, Psoroma and Collema. At higher altitudes in non-forest vegetation, it occurs mostly on soil or litter and is

associated with species of Cladia, Cladonia and Siphula decumbens. Wawea fruticulosa is also known from New Zealand where it is apparently rare.

206. Species A

Thallus minutely fruticulose to ± coarse granular, consisting of ecorticate, ± woolly or powdery branchlets, c. 50 µm thick x 0.5 mm tall, much-branched, erect or decumbent, dispersed or crowded, very brittle when dry. Hyphal filaments short, 2.5-4 µm thick, much branched. Photobiont green, unicellular, the cells c. 9-12 µm diam. Apothecia unknown.
Chemistry: unknown substances: thallus Pd-, K± pale yellowish, C-, KC+ red, UV-

The species resembles a Leprocaulon in morphology. It is widespread in Tasmanian rainforest but is particularly abundant in the North-West. It occurs on rough or smooth bark or amongst epiphytic bryophytes in moist, usually shaded habitats. It is superficially similar to Bactrospora sp. but differs in its fruticulose thallus and the C-, KC+ red reaction.

207. Species B

Thallus crustose, thin, uneven, often minutely cracked, pale whitish grey, bound by a thin black prothallus at the margin. Apothecia 0.5-0.7 mm diam., sessile to ± immersed at first, becoming emergent and partially or completely surrounded by a roughened, fissured thalline margin at least when young. Proper margin thin, glossy, ± translucent to pale brown. Disc dark brown or blackish, often ± densely pale grey pruinose, plane, undulate, often convex in older fruits. Epithecium red-brown, K-. Hymenium colourless (or pale reddish brown in old apothecia), c. 60-90 µm thick. Hypothecium pale brown or reddish brown, K+ yellow (fading). Paraphyses simple, separating easily in K, to 2 µm thick. Spores simple, hyaline, 8/ascus, broadly fusiform, mostly slightly curved, 18-25 x 5-6 µm.
Chemistry: cortex K+ yellow

The species is locally common in rainforest at Little Fisher River where it is a pioneer of young, smooth-barked trunks or branches in clearings. Associated species include Coccotrema cucurbitula, Bacidia weymouthii, Catinaria sp., Phlyctella

subuncinata and Thelotrema lepadinum. It is also known from similar high altitude callidendrous forest in north-eastern Tasmania and from high altitude thamnic rainforest in the West but has probably been overlooked elsewhere. Tasmanian specimens have been examined by Mr. P. James who has suggested similarities to Herteliana taylori, a species known only from the British Isles and the Azores.

208. Species C

Thallus crustose, very thin, dull grey-green or ± absent, dissolving into conspicuous, bright lemon yellow, effuse, farinose soredia in diffuse, irregular, spreading, confluent patches. Photobiont green, unicellular, the cells 5-8 µm diam. Apothecia not seen.

Chemistry: unknown yellow pigment (soralia Pd-, C-, K+ orange)

The species is widespread and locally abundant on the lower parts of young smooth trunks, mainly in callidendrous rainforest. Atherosperma moschatum is usually the host tree.

# APPENDIX 2

## NUMERICAL METHODS

The aim of this section is to briefly describe the numerical methods used during the study. The mathematical background for the methods is not discussed and for this the reader is directed to basic source references.

### Ordination

Ordination is the arranging of sample stands in order of similarity (Mueller-Dombois and Ellenberg 1974) and, at its simplest level, is performed in one dimension with the stands in a linear sequence. However, it is mostly used to order samples in a multidimensional space. Ordination enables trends in variation to be observed and these can often be explained in terms of environmental gradients, thus illustrating assertions based initially on field observations. It may also enable the recognition of clusters, or demonstrate the relationships between them. Its effectiveness in these roles has been illustrated in parts IIIB and IIIC of this thesis. Several methods of ordination have been developed over the years [see Grieg-Smith (1983) and Minchin (1983) for reviews].

#### 1. Detrended Correspondence Analysis (DCA)

DCA is an improved version of Reciprocal Averaging (RA) (see Hill 1973). Given a set of ecological data consisting of samples (quadrats) containing certain species, RA begins with a set of species scores from which it defines the scores of the samples as the mean of the scores of the constituent species. It then derives new species scores as the average of the scores of the samples in which they occur. These new species scores are then used to compute new sample scores. The process continues until the species and sample scores stabilise and a one dimensional ordination of both species and samples is derived. Other possible "solutions" which have the same reciprocal averaging property form subsequent, lower order axes of the ordination.

DCA was developed by Hill and Gauch (1980) to overcome two major faults of RA: firstly, that the second axis of the ordination

was simply a mathematical artefact and reflected an arching of the first axis and, secondly, that equal differences between samples in their species composition were not necessarily reflected by equal distances along the axis (or gradient). Thus points at the extremes of the axis tended to be squashed together.

These faults are overcome in DCA by the manipulations of "detrending" and "rescaling" respectively [see Hill and Gauch (1980) and Hill (1979a) for detailed discussion]. However, with respect to "detrending", Hill (op. cit.) observes that although an independent second axis is derived, third and higher axes may still suffer from similar "arching" defects. Indeed, Minchin (1983) found that in his study, the third axis only reflected a spurious "twisting" of the two-dimensional surface defined by the first two axes of the ordination.

DCA is undertaken using the computer program DECORANA (Hill 1979a). It is considered a good general purpose ordination method with the particular advantage of being quick and cheap with respect to computing time, particularly where large data sets are involved. However, DCA has difficulty in coping with extreme discontinuities (Hill and Gauch 1980) and outlying samples (or species) should be excluded from the analysis. At times, outliers may be recognised only after a preliminary run.

Rare species (say < 5% frequency) and samples containing few species (e.g. < 3) should also be excluded because their positions in the ordination will be determined by an average of a very few values. In practice, this causes few problems because rare species are unlikely to alter the overall nature and floristic affinities of the samples, except if they are concentrated in a single stand. Samples with few species, such as "pure stands", can always be positioned manually in the ordination by calculating the average of the score(s) of their constituent species.

## 2. Non-metric Multi-dimensional Scaling (NMDS)

NMDS is a technique initially developed for psychologists and is described in detail by Kruskal (1964). Its application to ecology is discussed by Prentice (1977) and other authors (e.g. Grieg-Smith 1983, p. 272-274).

From a matrix of similarities between pairs of objects, e.g. quadrats or species, NMDS attempts to find a configuration of these

objects such that the distances between them are, as much as possible, in the same rank order (not relative magnitude) as their similarities. The number of dimensions in which this is undertaken is specified in advance and may be arbitary or determined by a preliminary ordination using some other technique. A starting configuration of the points (random or pre-determined by an ordination) is also specified. NMDS computes the distances between the points in the ordination and compares them to their similarities. The degree of departure from a perfect fit is termed "stress" and each successive computation adjusts the configuration slightly in order to reduce stress. The process continues until stress stabilises or ceases to decrease appreciably.

NMDS can be undertaken using the computer program ALSCAL (Young and Lewyckyj 1979). A major problem of the method is its expense with respect to computer time which limits the size of the data set that can be analysed. In the present study, co-ordinates derived by DCA were used as the starting configuration.

**Classification**

Numerical classification can be undertaken using a large array of techniques (e.g. see Pielou 1984) which can essentially be divided into two main types: agglomerative and divisive. The advantages of numerical classification have been discussed on p.167. Briefly, these are seen as their apparent objectivity in comparison to intuitively derived classifications, and their ability to rapidly sort large data sets. However, the former is limited by a significant user input which is required to interpret the results. Polythetic classification methods have the advantage of operating on an overall picture of species composition instead of being based on the recognition of character species. However, all numerical methods are disadvantaged by the fact that they only operate on species performance measures (e.g. cover) whereas traditional phytosociological techniques are based on a broad spectrum of experience and perception of species and habitat factors.

1. Two-way Indicator Species Analysis (Twinspan)

Two-way Indicator Species Analysis is a polythetic, divisive classification method which classifies both quadrats and species. It yields a two-way table analogous to that produced by traditional, manual phytosociological techniques, as well as a key to the quadrat classification by recognising diagnostic species for each step of the hierarchy. The method is undertaken by the program TWINSPAN (Hill 1979b) and is based on the technique "Indicator Species Analysis" described by Hill et al. (1975).

Twinspan is based on reciprocal averaging (RA). The data are ordinated, species which characterise the extremes of the RA axis are identified as indicator species, and the configuration of samples is divided into two clusters near the middle. Each cluster is then re-ordinated and split and the process continues until a minimum, pre-determined number of samples per cluster is reached. Three steps, each involving separate ordinations, are involved prior to each division. The process is described in detail by Hill (1979b, p.6).

Quantitative values of species performance (e.g. cover) are incorporated into the analysis as "pseudospecies". Thus given the Braun-Blanquet scale of abundance (Table 9), a sample in which species X scores a cover of 3 contains "pseudospecies X1", "pseudospecies X2" and "pseudospecies X3". A sample in which the same species has a cover score of 2 contains only the first two pseudospecies. Limits of the pseudospecies (termed "cut levels") are determined by the user and a wise choice of these is critical.

In the present study, it was found that using two pseudospecies produced the best results. The first pseudospecies accounts for all insignificant cover values, scored as '+' by the Braun-Blanquet scale and as '1' in this study (see Table 9). The second accounts for all other values of cover. Thus a species has only three possible states: absent, hardly present (pseudospecies 1) and present (pseudospecies 2). Pseudospecies 1 is then downweighted using an additional user-option in the computer program. The aim is to minimise as far as possible the influence of insignificant, often freakish occurrences of species which will blur the classification. A single category for all other levels of occurrence prevents over emphasising physically large species with intrinsically higher covers at the expense of physically small species which may nevertheless be critical in terms of determing which cluster or community a sample should be assigned

to. This decision is derived from the field observation that for many lichens, even a very small cover of < 5% represents a significant level of occurrence. This criterion may not necessarily hold in other vegetation and pseudospecies cut levels should be determined according to the problem at hand.

The classification of species derived by Twinspan was found to be of limited value. This is because the classification is produced by an "inverse" analysis, using the species as if they were quadrats. However, whereas species embody the bulk of information on the quadrats, the reverse is not true (see also p.306).

In general, Twinspan represents a cheap and easily interpretable method for sorting large data sets and is particularly useful for constructing starting configurations for subsequent manual resorting into an ordered two-way table.

## 2. Lance and Williams' Generalised Sorting Strategy

Lance and Williams' Generalised Sorting Strategy is an agglomerative classification method with a series of options incorporated within a single computer program (see Lance and Williams 1966). The options include nearest neighbour, furthest neighbour, median, centroid and group average sorting. In the present study, the flexible $\beta$ parameter is set to -0.25 for the median sorting option. Thus the distance between clusters P and Q, where Q is derived from the fusion of clusters M and N, is the distance from the centroid of P to the midpoint of the line joining the centroids of M and N (Pielou 1984). The method fuses pairs of clusters separated by the shortest distance in a continuous series of steps.

Median clustering is "weighted" and consequently all clusters are assigned equal weight, regardless of their size (i.e. number of constituent points). In fact, as a cluster increases in size during the fusion process, its dissimilarity with other clusters tends to increase, thus preventing large clusters from growing at the expense of smaller ones (Minchin 1983, p.378). Median clustering is hence of great practical value in data sets such as that from Little Fisher River (see part IIIC) where some communities were represented by relatively few quadrats. The clustering method used prevented these groups from being swamped by the larger, better-represented groups.

Mathematical details of median clustering are given by Pielou (1984, pp.63-76). The Lance and Williams' Sorting Strategy was

undertaken using the CSIRO Division of Land and Water Resources' Numerical Taxonomy Package (developed by L. Belbin, D. Faith and P. Minchin).

**Similarity measures**

Similarity measures are mathematical expressions which define the degree to which two objects (quadrats or species) are like each other. The complement of similarity is dissimilarity. In any set of data, the matrix of similarities (or dissimilarities) provides the raw material upon which the ordination or classification is then performed. Numerous indices of similarity have been developed (see Mueller-Dombois and Ellenberg 1974, pp. 212-233).

1. Quadrats

In the present study, quadrat dissimilarity was measured by "percentage distance" (Pielou 1984). This value is the complement of "percentage similarity" (Gauch and Whittaker 1972) as used by Bray and Curtis (1957). The measure has been variously referred to as Gleasons or Kulczynski's coefficients (Bray and Curtis op. cit.), Sorensen's value (Mueller-Dombois and Ellenberg 1974) and Czekanowski's index of similarity (Pielou 1984). The similarity between two stands is defined as the amount of abundance shared, divided by the average amount of abundance present, i.e.

$$\text{similarity} = \frac{w}{1/_2(a+b)}$$

where w = the sum of the minimum values of the species in common, and a and b are the sums of the values of all the species in each of the two stands. The maximum value possible (between two identical stands) is 1 and hence

$$\text{dissimilarity} = 1 - \frac{2w}{a+b}$$

2. Species

Species are often classified by simply inverting the data matrix and treating the species as if they were quadrats, a technique used by the method Twinspan. However, this is generally unsatisfactory because

(a) all of the information for a species is not entailed in the quadrats it occurs in, and

(b) species, unlike quadrats, do not occupy points on an environmental gradient but are spread along the gradient.

Two-Step is a specific method for calculating dissimilarity between species and was developed by Austin and Belbin (1982) for use with standard clustering methods, e.g. Lance and Williams' Strategy. It measures the degree to which two species have similar patterns of dissimilarity to all other species. The measure is asymetric and so attempts to define species groups with similar ecological ranges even when they do not occur in the same stands (Austin and Belbin 1980). Symetric measures, on the other hand, imply that if A always occurs with B then B will always occur with A, a criterion which is not upheld in practice when, for example, one of the two species involved is widely distributed whilst the other has a narrow range.

**The use of performance measures**

The Little Fisher River study (part IIIC) illustrated several aspects of the value of performance measures in numerical analyses (both ordination and classification). Preliminary analyses used presence/absence data as well as cover data. The results indicated that binary data embodies the great majority of the information present and that cover scores at best serve only to "tidy up" the result. This has serious implications where a choice must be made between collecting a small number of quadrats with accurate assessments of species cover or a significantly larger number of quadrats which record only species presence (see also Minchin 1983, p.332). It was also found that the use of actual covers, derived as the midpoints of the cover classes (see Table 9), inflated the importance of some species at the expense of others. The variable growth habit of lichens means that for some species, e.g. fruticose lichens such as Usnea, abundance is not as closely correlated with high cover as it is for most foliose or crustose lichens where increasing abundance is immediately transposed into a higher cover. Furthermore, several floristically and ecologically critical species are invariably very small and may contribute almost insignificant cover to the stand. It was found that a satisfactory compromise was achieved by downweighting the high cover values and using the raw cover-class scores (i.e. 1-6).